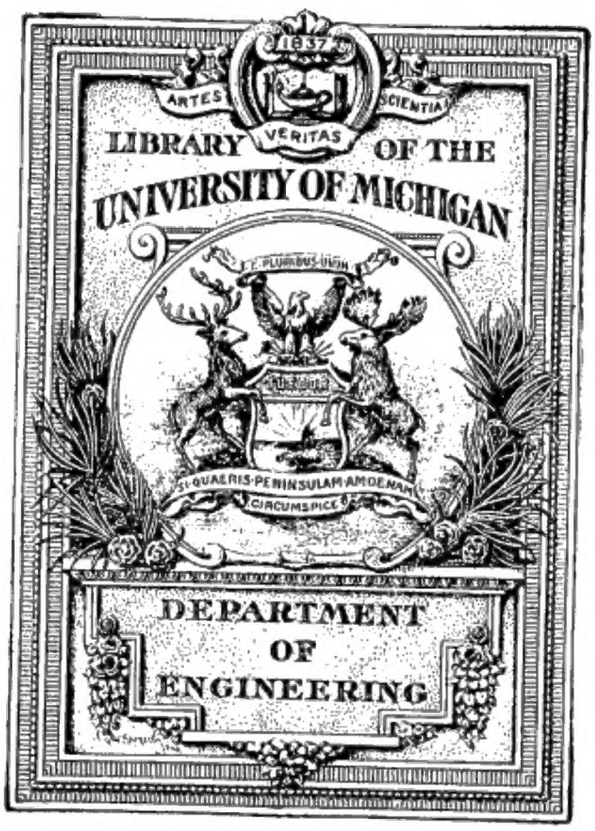
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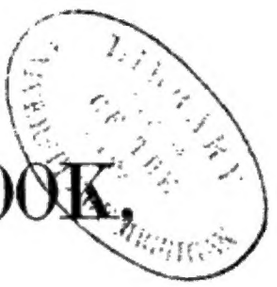
ARCHITECTS, ENGINEERS, SURVEYORS,

SOLICITORS,

AUCTIONEERS, LAND AGENTS, STEWARDS,

COUNTRY GENTLEMEN, AND OTHERS.

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A

GENERAL TEXT BOOK,

FOR THE

CONSTANT USE AND REFERENCE

OF

ARCHITECTS, ENGINEERS, SURVEYORS, SOLICITORS, AUCTIONEERS, LAND AGENTS, AND STEWARDS,

IN ALL THEIR SEVERAL AND VARIED PROFESSIONAL OCCUPATIONS;

AND FOR THE

ASSISTANCE AND GUIDANCE

OF

COUNTRY GENTLEMEN AND OTHERS

ENGAGED IN THE

TRANSFER, MANAGEMENT, OR IMPROVEMENT OF LANDED PROPERTY:

CONTAINING

THEOREMS, FORMULÆ, RULES, AND TABLES

IN

GEOMETRY, MENSURATION, AND TRIGONOMETRY;
LAND MEASURING, SURVEYING, AND LEVELLING; RAILWAY AND HYDRAULIC ENGINEERING;
TIMBER MEASURING; THE VALUATION OF ARTIFICERS' WORK,
ESTATES, LEASEHOLDS, LIFEHOLDS, ANNUITIES, TILLAGES, FARMING STOCK, & TENANT RIGHT:
THE ASSESSMENT OF PARISHES, RAILWAYS, GAS AND WATER WORKS;
THE LAW OF DILAPIDATIONS AND NUISANCES, APPRAISEMENTS AND AUCTIONS,
LANDLORD AND TENANT, AGREEMENTS AND LEASES.
TOGETHER WITH EXAMPLES OF VILLAS AND COUNTRY HOUSES.

BY

EDWARD RYDE,

CIVIL ENGINEER AND LAND SURVEYOR, AUTHOR OF SEVERAL PROFESSIONAL WORKS.

TO WHICH ARE ADDED SEVERAL CHAPTERS ON

AGRICULTURE AND LANDED PROPERTY.

BY

PROFESSOR DONALDSON,

AUTHOR OF SEVERAL WORKS ON AGRICULTURE.

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PREFACE.

THE design of this Book is not entirely due to me, but was suggested by the eminent Professional Publisher whose name appears at the foot of the title page. The necessity for its production became apparent from the many enquiries made of him for a work of this character, and when he did me the favor to consult me on the subject, it at once occurred to my mind that the Book should be one which if placed in the hands of my pupils would afford them the materials for the nucleus of that professional knowledge that should govern their pursuits in after-life; a volume to which men of all professions collateral to my own might constantly refer for assistance and information; a volume which would guide the possessor or agent of real property, alike in the transfer as in the improvement or management of his estates; and finally, a volume that would be found acceptable on the table and desk of every practical man and student throughout the kingdom.

In the preparation of such a work, an attempt at

complete originality would be as futile as it is unnecessary; so many matters of scientific detail, having long since become in a great measure common property; I have therefore in the first five chapters which treat of Arithmetic, Geometry, Mensuration, and Trigonometry, consulted established authorities, but especially I should mention Mr. LAWS' Edition of "*Dr. Gregory's Mathematics for Practical Men.*" There are also a few other instances of very minor importance, in which having found material ready to my hand, I have not hesitated to transcribe it (I hope honorably) to these pages, having acknowledged each instance as it occurs. The remaining matter, forming the great bulk of the work, has been an undertaking of immense labour; has occupied the leisure time of several years; and will I trust be found to answer the purposes for which it is intended.

If it may sometimes appear to competent persons that too great an importance has been given to trivial things, they must bear in mind that I have been writing for the benefit of all parties; alike for those who may be assumed to know but very little of the subjects treated of, as for those who are well informed upon them. On the other hand I must claim indulgence if any of my observations are not sufficiently in detail for the comprehension of the less skilled portion of my readers, both on account of the

very limited space at my command for the disposition of so many subjects, and the great difficulty an efficient person experiences in describing such things as appear to him so simple that he imagines every one must know them.

It is presumed that a very important feature of the work will be found in the numerous Tables with which its pages are interspersed. To the practical man Tables on many of the subjects which are herein contained are of unknown value, by affording much facility for calculation, and by greatly diminishing the chances of error.

The chapters upon Engineering, Surveying, Hydraulics, and Valuations are extended to a length commensurate only with the importance of the matters considered, and the necessity of expounding the many and varied rules by which operations of that kind are directed.

The Builders' Prices are intended to represent such a scale as will serve to remunerate the master tradesman for the outlay of his capital, his superintendence, and skill; and, although they are published at a time when unfortunately prices are influenced by a variety of operating causes, it is believed they will be found fair exponents of average charges. With this view they have been, in some instances, submitted to artificers themselves, for confirmation of my opinions; and the assistance rendered me in this particular by Mr. Powell, a plumber, painter,

and glazier, and Mr. Hopwood, an ironmonger, both of Pimlico, and men who have my confidence, and such patronage as is at my disposal in their respective businesses, has been such as to merit my acknowledgment here.

The chapters on Dilapidations and Nuisances, with the Law of Auction and Appraisements, were originally intended to be supplied by a barrister of eminence; but it appeared as the work progressed, that the printed authorities of which the publisher of this book is sole proprietor, aided by that knowledge and experience which fortune has enabled me to acquire, by the exercise of general professional business from a very early age, was sufficient to produce all that could be desired.

The examples of Villas and Country Houses are obtained from auxiliary sources: and the chapters on Landed Property, by Professor Donaldson, convey their own description of that gentleman's assistance on the work.

I should now conclude, but that I feel the aid of subordinates, when willingly and assiduously accorded in any undertaking, should meet with courteous acknowledgment. The names of my assistants, Mr. William Eve and Mr. Frank Harrow, have been already mentioned in

the book in connection with one of the most useful tables; but, in addition to the services there referred to, upon one or other of them has devolved the tedious and irksome task of reading for the correction of the press; (very often after the ordinary business of the day had been disposed of) so that I feel great pleasure in expressing the sense I entertain of this additional help.

I have only to add, that, if any errors are found, and the person who makes the discovery will be at the trouble of communicating with me, the correction shall be made in all future editions, the preparation of which I reserve to myself.

EDWARD RYDE.

Upper Belgrave Place,
Eaton Square, London.

1st December, 1853.

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BY

PROFESSOR DONALDSON.

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A

GENERAL TEXT BOOK,

ETC., ETC.

CHAP. I.

ARITHMETIC.

SECT. I.—*Notation.*

ARITHMETIC is the science of numbers.

To the head of notation we may refer the explanation of the principal symbols or characters employed to express operations or results in computation. Thus,

The sign + (*plus*) belongs to addition, and indicates that the numbers between which it is placed are to be added together. Thus, 5 + 7 expresses the sum of 5 and 7, or that 5 and 7 are to be added together.

The sign — (*minus*) indicates that the number which is placed after it is to be subtracted from that which precedes it. So, 9 — 3 denotes that 3 is to be taken from 9.

The sign ~ denotes *difference*, and is placed between two quantities when it is not immediately evident which of them is the greater.

The sign × (*into*), for multiplication, indicates the product of two numbers between which it is placed. Thus 8 × 5 denotes 8 times 5 or 40.

The sign ÷ (*by*), for division, indicates that the number which precedes it is to be divided by that which follows it; and the quotient that results from this operation is often represented by placing the first number over the second with a small bar between them. Thus, 15 ÷ 8 denotes that 15 is to be divided by 8, and the quotient is expressed thus $\frac{15}{8}$.

The sign =, two equal and parallel lines placed horizontally, is that of equality. Thus, 2 + 3 + 4 = 9, means that the sum of 2, 3, and 4, is equal to 9.

Inequality is represented by two lines so drawn as to form an angle, and placed between two numbers, so that the angular point turns towards the least. Thus, 7 > 4, and A > B, indicate that 7 is *greater than* 4, and the quantity represented by A *greater than* the quantity represented by B; and, on the other hand, 3 < 5 and C < D indicate that 3 is *less than* 5, and C *less than* D

Colons and double colons are placed between quantities to denote their proportionality. So, 3 : 5 : : 9 : 15, signifies that 3 are to 5 as 9 are to 15, or $\frac{3}{5} = \frac{9}{15}$.

The extraction of roots is indicated by the sign $\surd$, with a figure occasionally placed over it to express the *degree* of the root; or by a *fraction* (having unity for its numerator, and the figure expressing the *degree* of the root for its denominator) placed above and to the right of the quantity to have its root extracted; thus, $\surd 4$ or $4^{\frac{1}{2}}$, signifies the square root of 4; $\sqrt[3]{27}$, or $27^{\frac{1}{3}}$, the cube root of 27; $\sqrt[4]{16}$ or $16^{\frac{1}{4}}$, the fourth or biquadrate root of 16.

The raising of powers is expressed by a *whole* number similarly placed, the figure denoting the power to which the quantity is to be raised; thus, 6^2, signifies the square of 6; 8^3, the cube of 8; and 3^4, the fourth power of 3. The figures thus used to indicate the power, whether *whole* or *fractional* numbers, are termed *indices* or *exponents.*

When both operations are to be successively performed upon a quantity, that is, when some root is to be extracted, and then that root to be raised to some different power, the operation is very simply expressed by a fraction placed as before, the *denominator* of which indicates the *root* to be extracted, and the *numerator* the *power* to which that root is to be afterwards raised. Thus, $27^{\frac{2}{3}}$, denotes that the cube root of 27 is to be extracted, and that the root so obtained is to be squared, or raised to the second power. It is immaterial which operation is first performed, for the result would be the same whether we first extracted the cube root, as above, and then squared it, or whether we squared the number first, and then extracted the cube root of the power so obtained.

SECT. II.—*Proof of the first four Rules of Arithmetic.*

Simple as these four rules are, it is not unusual to commit errors in working them: it is, therefore, useful to possess modes of proof.

1. Now, *addition* may be proved by adding downwards, as well as upwards, and observing whether the two sums agree; or, by dividing the numbers, to be added into two portions, finding the sum of each, and then the sum of those two separate amounts. Thus, in the margin, the sum of the four numbers is 7355; the sum of the two upper ones 5857, of the two lower ones 1498, and *their* sum is 7355, the same as before.

2758	2758
3099	3099
469	
1029	5857
7355	469
	1029
	1498
	7355

2. The proof of *subtraction* is effected by adding the remainder to the subtrahend; if their sum agrees with the minuend the work is right, otherwise not.

3. *Multiplication* and *division* reciprocally prove each other.

There is also another proof for multiplication, known technically by the phrase *casting out the nines.* Add together the numbers from left to right in the multiplicand, dropping 9 whenever the sum exceeds 9, and carry on the remainder, dropping the nines as often as the amount is beyond them; and note the last remainder. Do the same with the multiplier and with the product; then multiply the first two remainders and cast the nines out of their product; if the remainder is equal to the last remainder, this is regarded as a test that the work is right. Thus, taking an example in multiplication, assume the figures in the multiplicand to amount to 6 above two nines, those in the multiplier to 6 above three nines, those in the product to 0 above six nines; the product 6×6 of the two first excesses is 36, or 0 above four nines: the coincidence of the two 0's is the proof. It is plain, however, that the proof will be precisely the same so long as the figures in the product be the same, whatever be their *order:* the proof, therefore, though ingenious, is defective*.

A similar proof applies to *division.*

SECT. III.—*Vulgar Fractions.*

Common or *Vulgar Fractions* are so denominated to distinguish them from another kind, hereafter to be mentioned, called *Decimal Fractions.*

A fraction is an expression for the value of any part of an integer, or *whole* number, such number being considered as *unity.* Thus, if a *pound* sterling be the *unit*, then a shilling will be the *twentieth* part of that unit, and *four pence* will be four-twelfths of that twentieth part. These, represented according to the usual notation of vulgar fractions, will be $\frac{1}{20}$ and $\frac{4}{12}$ of $\frac{1}{20}$, respectively.

The lower number of a fraction thus represented (denoting the number of parts into which the integer is supposed to be divided) is called the *denominator;* and the upper figure (which indicates the number of those parts expressed by the fraction) the *numerator.* Thus, in the fractions $\frac{5}{7}$, $\frac{8}{15}$, 7 and 15 are *denominators*, 5 and 8 *numerators.*

Vulgar fractions are divided into proper, improper, mixed, simple, compound, and complex.

Proper fractions have their numerators less than their denominators, as $\frac{3}{4}$, $\frac{5}{8}$, &c.

Improper fractions have their numerators equal to, or greater than, their denominators, as $\frac{4}{4}$, $\frac{12}{8}$, &c.

* The correctness of this proof, with the exception above specified, may be shewn algebraically, thus:—put M and N = the number of nines in the multiplicand and multiplier respectively, m and n their excesses; then, $9M + m$ = the multiplicand, and $9N + n$ = the multiplier, and the product of those factors will be $= 81MN + 9Mn + 9Nm = mn$; but the three first terms are each a precise number of nines; because one of the factors in each is so; these, therefore, being neglected, there remains mn to be divided by nine; but mn is the product of the two former excesses: therefore the truth of the method is evident. Q. E. D.

Mixed fractions, or numbers, are those compounded of whole numbers and fractions, as $7\frac{5}{8}$, $12\frac{3}{4}$, &c.

Simple fractions are expressions for parts of whole numbers, as $\frac{4}{9}$, $\frac{5}{6}$, &c.

Compound fractions are expressions for the parts of given fractions, as $\frac{3}{4}$ of $\frac{5}{8}$, $\frac{2}{3}$ of $\frac{7}{11}$, &c.

Complex fractions have either one or both terms fractional numbers, as $\frac{5\frac{2}{3}}{24}$, $\frac{12}{14\frac{3}{4}}$, $\frac{6\frac{5}{8}}{12\frac{2}{3}}$, &c.

The value of a fraction is not altered by multiplying or dividing both its numerator and denominator by the same number; thus, $\frac{1}{2}$, $\frac{2}{4}$, $\frac{12}{24}$, $\frac{144}{288}$, are all equal, although successively multiplied by 2, 6, and 12.

Any number which will divide two or more numbers without remainder, is called their *common measure.*

REDUCTION OF VULGAR FRACTIONS.

This consists principally in changing them into a more commodious form for the operations of addition, subtraction, &c.

CASE I.—*To reduce fractions to their lowest terms.*

Rule.—Divide the numerator and denominator of a fraction by any number that will divide them both, without a remainder; the quotient again, if possible, by any other number: and so on, till 1 is the greatest divisor.

Thus, $\frac{1470}{2205} = \frac{294}{441} = \frac{98}{147} = \frac{14}{21} = \frac{2}{3}$, where 5, 3, 7, 7, respectively, are the divisors.

Or, $\frac{1470}{2205} = \frac{2}{3}$, by dividing at once by 735.

Note.—This number 735 is called the *greatest* common measure of the terms of the fraction: it is found thus—Divide the greater of the two numbers by the less; the last divisor by the last remainder, and so on till nothing remains: the last divisor is the greatest common measure required.

CASE II.—*To reduce an improper fraction to its equivalent whole or mixed number.*

Rule.—Divide the numerator by the denominator, and the quotient will be the answer: as is evident from the nature of division.

CASE III.—*To reduce a mixed number to its equivalent improper fraction; or a whole number to an equivalent fraction having any assigned denominator.*

Rule.—This is, evidently, the reverse of Case II.; therefore multiply the whole number by the denominator of the fraction, and add the numerator to obtain the numerator of the fraction required.

Ex.—Reduce $22\frac{11}{43}$ to an improper fraction, and 20 to a fraction whose denominator shall be 274.

$(22 \times 43) + 11 = 957$ new numerator, and $\frac{957}{43}$ the 1st fraction.

$20 \times 274 = 5480$ new numerator, and $\frac{5480}{274}$ the 2nd fraction.

CASE IV.—*To reduce a compound fraction to an equivalent simple one.*

Rule.—Multiply all the numerators together for the numerator, and all the denominators together for the denominator, of the simple fraction required.

If part of the compound fraction be a mixed or a whole number, reduce the former to an improper fraction, and make the latter a fraction by placing 1 under the numerator.

When like factors are found in the numerators and denominators, cancel them both.

Ex.—Reduce $\frac{2}{3}$ of $\frac{3}{4}$ of $\frac{5}{7}$ of $\frac{7}{9}$ of $\frac{8}{11}$ to a simple fraction.

$$\frac{2\times3\times5\times7\times8}{3\times4\times7\times9\times11}=\frac{2\times5\times8}{4\times9\times11}=\frac{1\times5\times8}{2\times9\times11}=\frac{1\times5\times4}{1\times9\times11}=\frac{20}{99}$$

Here the 3 and 7 common to numerator and denominator are first cancelled; then the fraction is divided by 2; and then by 2 again.

Case V.—*To reduce fractions of different denominators to equivalent fractions having a common denominator.*

Rule.—Multiply each numerator into all the denominators except its own, for new numerators; and all the denominators together for a common denominator.

Ex.—Reduce $\frac{2}{3}$, $\frac{6}{7}$, and $\frac{5}{9}$, to equivalent fractions having a common denominator.

$$\left.\begin{aligned}2\times7\times9&=126\\6\times3\times9&=162\\5\times3\times7&=105\end{aligned}\right\}\text{the numerators.}$$

$3\times7\times9=189$, the common denominator.

Hence the fractions are $\frac{126}{189}$, $\frac{162}{189}$, $\frac{105}{189}$, or $\frac{42}{63}$, $\frac{54}{63}$, $\frac{35}{63}$, when divided by 3.

Hence, also, it appears that $\frac{2}{3}$ exceed $\frac{5}{9}$, and that $\frac{6}{7}$ exceed $\frac{2}{3}$.

ADDITION AND SUBTRACTION OF FRACTIONS.

Rule.—If the fractions have a common denominator, add or subtract the numerators, and place the sum or difference as a new numerator over the common denominator.

If the fractions have not a common denominator, they must be reduced to that state before the operation is performed.

In addition of mixed numbers, it is usually best to take the sum of the integers, and that of the fractions, separately; and then *their* sum, for the result required.

MULTIPLICATION AND DIVISION OF FRACTIONS.

Rule 1. To multiply a fraction by a whole number, *multiply* the *numerator* by that number, and retain the denominator:—Or, *divide* the *denominator* by the same number, (if a multiple of it,) and retain the numerator.

2. To divide a fraction by a whole number, *multiply* the *denominator* by that number, and retain the numerator:—Or, *divide* the *numerator* by the same number, (if a multiple of it,) and retain the denominator.

3. To multiply two or more fractions is the same as to take a fraction of a fraction; and is, therefore, effected by taking the product of the numerators for a new numerator, and of the denominators for a new denominator. (The product is evidently smaller than either factor when each is less than unity.)

4. To divide one fraction by another, invert the divisor, and proceed as in multiplication. (The quotient is always greater than the dividend when the divisor is less than unity.)

Sect IV.—*Decimals.*

The embarrassment and loss of time occasioned by the computation of quantities expressed in vulgar or ordinary fractions, have inspired the idea of *fixing* the denominator so as to know what it is without actually expressing it. Hence originate two dispositions of numbers, *decimal fractions* and *complex numbers*. Of the latter, such, for example, as when we express lineal measures in yards, in feet (or thirds of a yard), and inches (or twelfths of a foot), we shall treat in the following section, and shall here confine ourselves to the former.

Decimal fractions, or substantively *decimals*, are fractions always having some power of *ten* for their denominator; but for the sake of brevity only the numerator is expressed, being written as a *whole* number with a dot placed on its left hand, which dot determines the value of the denominator, the number of cyphers in the denominator being always equal to the number of figures to the *right* of the dot, or as it is termed decimal point; if the number of significant figures in the numerator is not sufficient, cyphers are added to the left hand. It is evident that the values of decimals decrease in the same tenfold proportion from the point towards the *right* hand, as those of integers increase towards the left: thus

The vulgar fraction,		$\frac{1}{10}$	is written	·1
,,	,,	$\frac{1}{100}$	,,	·01
,,	,,	$\frac{1}{1000}$	,,	·001
,,	,,	$\frac{1}{10000}$	,,	·0001
,,	,,	$\frac{7}{10}$	,,	·7
,,	,,	$\frac{43}{100}$	,,	·43
,,	,,	$\frac{125}{10000}$	,,	·0125
The vulgar fraction,		$7\frac{3}{10}$	is written	7·3
,,	,,	$42\frac{85}{100}$	,,	42·85
,,	,,	$57\frac{217}{1000}$	,,	57·217
		&c.		&c.

The value of a decimal fraction is not altered by cyphers on the right hand: for ·500 or $\frac{500}{1000}$, is in value the same as $\frac{5}{10}$, or ·5, that is $\frac{1}{2}$.

When decimals terminate after a certain number of figures, they are called *finite*, as $\cdot 125 = \frac{125}{1000} = \frac{1}{8}$, $\cdot 958 = \frac{958}{1000} = \frac{237}{250}$.

When one or more figures in the decimal become repeated, it is called a *repeating* or *circulating* decimal; and a dot is placed over the figure to

be repeated, if only one, or if more than one, over the first and last figures; thus:—

·333333, &c.	$=\frac{1}{3}$	is written	$\cdot\dot{3}$
·666666, &c.	$=\frac{2}{3}$	,,	$\cdot\dot{6}$
·428571428571, &c.	$=\frac{3}{7}$	,,	$\cdot\dot{4}28571\dot{4}$
·29504504, &c.	$=\frac{131}{444}$	,,	$\cdot 29\dot{5}0\dot{4}$

When the circulating portion of the decimal is preceded by other figures which do not circulate, (as in the last example,) it is called a *mixed circulate.*

Rules for the management of this latter kind of decimals are given by several authors; but, in general, it is more simple and commodious to perform the requisite operations by means of the equivalent vulgar fractions, the method of obtaining which is given in Case III.

Reduction of Decimals is a rule by which the known parts of given integers are converted into equivalent decimals, and *vice versâ.*

Case I.—*To reduce a given vulgar fraction to an equivalent decimal.*

Rule.—Annex as many cyphers to the numerator as may be necessary then divide by the denominator, and point off in the quotient as many places of decimals as the number of cyphers added to the numerator; if the quotient does not contain so many figures, the deficiency must be made up by cyphers placed on the *left* hand.

Case II.—*Any decimal being given to find its equivalent vulgar fraction; or to express its value by integers of lower denominations.*

Rule.—When the equivalent vulgar fraction is required, place under the decimal as a denominator a unit, with as many cyphers as there are figures in the proposed decimal; and let the fraction so constituted be reduced to its lowest terms.

Or, if the value of the decimal be required in lower denominations, multiply the given decimal by the number of parts in the next less denomination contained in its integer; and point off, from right to left, as many figures of the product as there were places in the given decimal. Multiply the decimal last pointed off by the value of its integer, in the next inferior order, pointing off the same number of decimals as before; and thus continue the process to the lowest integer, or until the decimals cut off become all cyphers; then will the several numbers on the left of the separating points, together with the remaining decimal, if any, express the required value of the given decimal.

Case III.—*To reduce a circulating decimal to its equivalent vulgar fraction.*

Rule.—Take the figures in the decimal and place them as a whole number for the numerator, and under them for a denominator as many 9's as there are figures in the circulate, and the fraction thus formed will be equivalent in value to the given decimal.

If the decimal is a *mixed* circulate, subtract the finite part (or the figures which are not repeated) from the whole mixed circulate, (both considered as whole numbers,) for the numerator; and for the denominator, take as many 9's as there are figures in the circulating portion of

the decimal, with as many cyphers to the right as there are figures in the finite portion of the same.

Examples.

The circulate	$\cdot\dot{3}$	$= \frac{3}{9}$	$= \frac{1}{3}$
„	$\cdot\dot{0}\dot{6}$	$= \frac{6}{99}$	$= \frac{2}{33}$
„	$\cdot\dot{5}4\dot{9}$	$= \frac{549}{999}$	$= \frac{61}{111}$
„	$7\cdot630\dot{}$	$= 7\frac{630}{999}$	$= 7\frac{70}{111}$
The *mixed* circulate	$\cdot640\dot{9}$	$= \frac{6409-64}{9900}$	$= \frac{1421}{2200}$
„	$5\cdot29504\dot{}$	$= 5\frac{29504-29}{999000}$	$= 5\frac{1311}{4444}$.

Sect. V.—*Duodecimals.*

Fractions whose denominators are multiples of 12, as 144, 1728, &c., are called *duodecimals;* and the division and sub-division of the integer are *understood* without being expressed, as in *decimals.* The method of operating by this class of fractions is principally in use among artificers, in computing the contents of work, of which the dimensions are taken in *feet, inches,* and *twefths* of an inch.

Rule.—Set down the two dimensions to be multiplied together, one under the other, so that feet shall stand under feet, inches under inches, &c. Multiply each term in the multiplicand, beginning at the lowest, by the feet in the multiplier, and set the result of each immediately under its corresponding term, observing to carry 1 for every 12, from the inches to the feet. In like manner, multiply all the multiplicand by the inches of the multiplier, and then by the twelfth parts, setting the result of each term *one* place removed to the right hand when the multiplier is inches, and *two* places when the parts become the multiplier. The sum of these successive products will be the answer required.

Or, instead of multiplying by the inches, &c., take such parts of the multiplicand as these are of a foot.

Examples.

1. Multiply 12 *ft.* $7\frac{1}{3}$ *ins.* by 7 *ft.* $3\frac{3}{4}$ *ins.*

ft.	*ins.*	′			
12	7	4			
7	3	9			
88	3	4			
3	1	10	0		
	9	5	6	0	
92	2	7	6	0	

or,

ins.
3 = $\frac{1}{4}$ of 1 ft.
9′ = $\frac{1}{4}$ of 3 ins.

ft.	*ins.*	′	
12	7	4	
		7 ft.	
88	3	4	
3	1	10	
	9	$5\frac{1}{2}$	
92	2	$7\frac{1}{2}$	

2. Multiply 35 *ft.* 4½ *ins.* into 12 *ft.* 3⅓ *ins.*

ft.	*ins.*	′			
35	4	6			
12	3	4			
424	6	0			
8	10	1	6		
	11	9	6	0	
434	3	11	0	0	

ins.
3 = ¼ of 1 ft.
4′ = ⅓ of 3 ins.

or,

ft.	*ins.*	′
35	4	6
		12 ft.
424	6	0
8	10	1½
	11	9½
434	3	11

The feet in the answers are square feet, but the numbers standing in the place of inches are not square inches, but twelfth parts of square feet, each part being equal to 12 square inches; and the numbers in the *third* place being twefth parts of these are square inches; in like manner, if the operation be carried further, every successive place will be a twelfth part of that preceding it.

SECT. VI.—*Powers and Roots.*

1.—*To Extract the Square Root.*

Rule.—Divide the given number into periods of two figures each, by setting a point *over the place of units*, another over the place of hundreds, and so on over every second figure, both to the left hand in integers, and to the right hand in decimals. Find the greatest square in the first period on the left hand, and set its root on the right hand of the given number, after the manner of a quotient figure in division. Subtract the square thus found from the said period, and to the remainder annex the two figures of the next following period, for a dividend. Double the root abovementioned for a divisor; and find how often it is contained in the said dividend, exclusive of its right-hand figure; and set that quotient figure both in the quotient and divisor. Multiply the whole augmented divisor by this last quotient figure, and subtract the product from the said dividend, bringing down to it the next period of the given number, for a new dividend. Repeat the same process, viz., find another new divisor, by doubling all the figures now found in the root; from which, and the last dividend, find the next figure of the root as before; and so on through all the periods, to the last.

Note.—The best way of doubling the root, to form the new divisors, is by adding the last figure always to the last divisor, as appears in the following Example.—Also, after the figures belonging to the given number are all exhausted, the operation may be continued into decimals at pleasure, by adding any number of periods of cyphers, two in each period.

Example.

Find the square root of 17·3056

```
                . . .
  17·3056(4·16 the root: in which the number of
    16          decimal places is the same as the
  ------        number of decimal *periods* into which
  81 | 130      the given number was divided.
   1 |  81
  ---------
 826 | 4956
   6 | 4956
     -------
     . . . .
     =======
```

2.—*To Extract Cube and higher Roots.*

The rules for extracting the cube and higher roots, are very tedious in practice: on which account it is advisable to work by means of logarithms.

SECT. VII.—*Properties of Numbers.*

To render these intelligible, we shall here collect a few definitions.

Def. 1. A *unit*, or *unity*, is the representation of any thing considered individually, without regard to the parts of which it is composed.

2. An *integer* is either a unit or an assemblage of units; and a *fraction* is any part or parts of a unit.

3. A *multiple* of any number is that which contains it some exact number of times.

4. One number is said to *measure* another, when it divides it without leaving any remainder.

5. And if a number exactly divides two, or more numbers, it is then called their *common measure*.

6. An *even number*, is that which can be halved, or divided into two equal parts.

7. An *odd number*, is that which cannot be halved, or which differs from an even number by unity.

8. A *prime number*, is that which can only be measured by 1, or unity.

9. One number is said to be *prime* to another when unity is the only number by which they can both be measured.

10. A *composite number*, is that which can be measured by some number greater than unity.

11. A *perfect number*, is that which is equal to the sum of all its divisors, or aliquot parts:—thus $6 = \frac{6}{2} + \frac{6}{3} + \frac{6}{6}$.

Prop. 1. The sum or difference of any two *even* numbers is an *even* number.

2. The sum or difference of any two *odd* numbers is *even;* but the sum of three *odd* numbers is *odd.*

3. The sum of any *even* number of *odd* numbers is *even;* but the sum of any *odd* number of *odd* numbers is *odd.*

4. The sum or difference of an *even* and an *odd* number is *odd.*

5. The product of any number of *even* numbers is *even;* and any power of an *even* number is *even.*

6. The product of any number of *odd* numbers is *odd;* and every power of an *odd* number is *odd.*

7. The product of any number of *even* numbers, by any number of *odd* numbers, is *even.*

8. An *odd* number cannot be divided by an *even* number, without a remainder.

9. If an *odd* number divides an *even* number, it will also divide the half of it.

10. If a number consist of many parts, and each of those parts have a common divisor d, then will the whole number, taken collectively, be divisible by d.

11. Neither the sum nor the difference of two fractions, which are in their lowest terms, and of which the denominator of the one contains a factor not common to the other, can be equal to an integral number.

12. If a square number be either multiplied or divided by a square, the product or quotient is a square; and conversely, if a square number be either multiplied or divided by a number that is not a square, the product or quotient is not a square.

13. The product arising from two different prime numbers cannot be a square number.

14. The product of no two different numbers prime to each other can make a square, unless each of those numbers be a square.

15. The square root of an integral number, that is not a complete square, can neither be expressed by an integer nor by any rational fraction.

16. The cube root of an integer that is not a complete cube cannot be expressed by either an integer or a rational fraction.

17. Every prime number greater than 2, is of one of the forms $4n + 1$, or $4n - 1$.

18. Every prime number greater than 3, is of one of the forms $6n + 1$ or $6n - 1$.

19. No algebraical formula can contain prime numbers only.

20. The number of prime numbers is infinite.

21. The first twenty prime numbers are 1, 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61, and 67.

22. A square number cannot terminate with an *odd* number of cyphers.

23. If a square number terminate with a 4, the last figure but one (towards the right hand) will be an *even* number.

24. If a square number terminate with 5, it will terminate with 25.

25. If a square number terminate with an *odd* digit, the last figure but one will be *even*; and if it terminate with any *even* digit, except 4, the last figure but one will be *odd*.

26. No square number can terminate with two equal digits, except two *cyphers* or two *fours*.

27. No number whose last, or right-hand digit is 2, 3, 7, or 8, is a square number.

28. If a cube number be divisible by 7, it is also divisible by the cube of 7.

29. The difference between any integral cube and its root is always divisible by 6.

30. Neither the sum nor the difference of two cubes can be a cube.

31. A cube number may end with any of the natural numbers 1, 2, 3, 4, 5, 6, 7, 8, 9 or 0.

32. If any series of numbers, beginning from 1, be in continued geometrical proportion, the 3rd, 5th, 7th, &c. will be squares; the 4th, 7th, 10th, &c. cubes; and the 7th, of course, both a square and a cube.

33. All the powers of any number that end with either 5 or 6, will end with 5 or 6, respectively.

34. Any power, n, of the natural numbers, 1, 2, 3, 4, 5, 6, &c. has as many orders of differences as there are units in the common exponent of all the numbers; and the last of those differences is a constant quantity, and equal to the continual product $1 \times 2 \times 3 \times 4 \times \ldots\ldots \times n$ continued till the last factor, or the number of factors be n, the exponent of the powers. Thus,

The 1st powers 1, 2, 3, 4, 5, &c., have but one order of differences 1 1 1 1 &c., and that difference is 1.

The 2nd powers 1, 4, 9, 16, 25, &c., have two orders of differences 3 5 7 9
2 2 2

of which the last is constantly $2 = 1 \times 2$.

The 3rd powers 1, 8, 27, 64, 125, &c., have three orders of differences 7 19 37 61
12 18 24
6 6

of which the last is $6 = 1 \times 2 \times 3$.

In like manner, the 4th, or last, differences of the 4th powers, are each $= 24 = 1 \times 2 \times 3 \times 4$; and the 5th, or last differences of the 5th powers, are each $125 = 1 \times 2 \times 3 \times 4 \times 5$.

35. If unity be divided into any two unequal parts, the sum of the square of either of those parts added to the other is the same. Thus, of the two parts $\frac{1}{5}$ and $\frac{4}{5}$, $\frac{1}{5} + (\frac{4}{5})^2 = \frac{4}{5} + (\frac{1}{5})^2 = \frac{21}{25}$; so, again, of the parts $\frac{2}{5}$ and $\frac{3}{5}$, $\frac{2}{5} + (\frac{3}{5})^2 = \frac{3}{5} + (\frac{2}{5})^2 = \frac{19}{25}$.

For the demonstrations of these and a variety of other properties of numbers, those who wish to pursue this curious line of inquiry may consult Legendre "Sur la Théorie des Nombres," the "Disquisitiones Arith-

meticæ" of Gauss, or Barlow's "Elementary Investigation of the Theory of Numbers."

Also, for the highly interesting properties of *Circulating Decimals*, and their connexion with *prime numbers*, consult the curious works of the late Mr. H. Goodwyn, entitled "A First Centenary," and "A Table of the Circles arising from the Division of a Unit by all the Integers from 1 to 1024."

Sect. VIII.—*Logarithms.*

As Logarithms are so fully described in most elementary treatises on Arithmetic, and as a knowledge of their nature and properties is unnecessary to their application to the purposes of calculation, we shall here only explain the manner of using the accompanying tables.

By an inspection of Table II., which contains the logarithms of all numbers from 1 to 100, it will be seen that each logarithm consists of two distinct parts, separated by a decimal point; thus, the logarithm of 13 is 1·113943; the number to the left of the decimal point (or 1 in the above example) is called the *index* or *characteristic**, and its value depends *only* upon the *number of digits* in the quantity whose logarithm it is, without any regard to the *value* of that quantity, and it is always 1 less than that number of digits; thus, in the example, the characteristic of the logarithm of 13, which contains two digits, is 1, or one less than that number; and it will be seen from the Table, that 1 is the characteristic of all the logarithms from 10 to 99, but that, for numbers below 10, the index is 0, and for 100 is 2, in each case 1 less than the number of digits in the quantity of whose logarithm it is the characteristic. The characteristic, therefore, of the logarithms of all numbers

equal to	or greater than	1	and less than	10	is 0·
„	„	10	„	100	„ 1·
„	„	100	„	1000	„ 2·
„	„	1000	„	10000	„ 3·
„	„	10000	„	100000	„ 4·
		&c.		&c.	&c.

When the quantity is less than unity, the characteristic of its logarithm becomes negative, and its value is determined by the number of cyphers which occur between the decimal point and the first significant figure (the fraction being decimally expressed), and is always 1 greater than such number of cyphers; or it is equal to the difference in the number of figures in the numerator and decimal denominator; thus, the characteristic of the logarithm of

* In order to avoid confusion from the use of the word index to signify two things, we shall throughout this work employ the term *characteristic* when speaking of logarithms, and *index* when speaking of roots or powers.

·1	or	$\frac{1}{10}$	is $\overline{1}$·*
·01	„	$\frac{1}{100}$	„ $\overline{2}$·
·001	„	$\frac{1}{1000}$	„ $\overline{3}$·
·0001	„	$\frac{1}{10000}$	„ $\overline{4}$·
&c.		&c.	&c.

The *decimal* part of the logarithm, or that lying to the right of the decimal point, is called the *mantissa*, and depends entirely on the *relative* value of the figures composing the quantity whose logarithm it is, and not at all upon the actual *numerical* value of that quantity; thus, in the example already given, the decimal part of the logarithm of 13 is ·113943, which is also the decimal part of the logarithm of 1·3, or 130, or 1300, for in each case the 1 and the 3 have the same *relative* value. So that the decimal portion of a logarithm is always the same for the same figures, and is not altered by the addition of any number of cyphers either to the right or to the left hand of those figures, or what is equivalent, by the multiplication or division of the quantity by 10, or any power of 10; it is only the characteristic of the logarithm which alters its value, 1 being *added* to the characteristic for every 10 by which the quantity is *multiplied*, or *subtracted* from it for every 10 by which the quantity is *divided*. Thus,

the logarithm of	745800	being	5·872622
that of	74580	is	4·872622
„	7458	„	3·872622
„	745·8	„	2·872622
„	74·58	„	1·872622
„	7·458	„	0·872622
„	·7458	„	$\overline{1}$·872622
„	·07458	„	$\overline{2}$·872622
„	·007458	„	$\overline{3}$·872622

It must be borne in mind, that in the logarithm of a fractional quantity, it is only the *characteristic* which has a *negative* value, and that the decimal part of a logarithm is always positive. It is, however, sometimes convenient to have the whole logarithm expressed, negatively, both characteristic and decimal; for which purpose, subtract the last right hand figure in the decimal portion from 10, and all the others from 9, and the result will be what is termed the *arithmetical complement* of the decimal, to which prefix the former characteristic less 1, and the result will be a negative logarithm, equivalent in value to the original logarithm having only a negative characteristic; for example, the logarithm of ·07458, as above, is $\overline{2}$·872622, which is equivalent to — 1·127378. It is also frequently convenient to take the *arithmetical complement* of the whole logarithm, and this is obtained by subtracting the right hand figure of the decimal from 10, and all the others from 9, including the characteristic

* The negative sign (—) is always placed *above* the characteristic, thus $\overline{2}$, instead of before it, in order to avoid its being misunderstood for the sign of subtraction.

when *positive*, but if *negative* it must be *added* to 9. Thus, the arithmetical complement

of 3·146128 is 6·853872
„ $\bar{2}$·076276 „ 11.923714
„ $\bar{5}$·322839 „ 4·677161
„ $\bar{1}$·986772 „ 10·013228

USE OF THE TABLES.

To find the logarithm of any given number.

If the number is less than 100, its logarithm will be found in Table II., with its proper characteristic prefixed; but if the number contains more than two figures, its logarithm may be found from Table I. as follows:—If there are only three figures in the number, look for that number in the first column of the table, and on the same line in the next column to the right, under 0, will be found the decimal portion of the required logarithm, to which the proper characteristic must be prefixed, according to the rules which we have just explained. If the quantity contains four figures, look for the first three figures in the first column as before, and the four last figures of the logarithm of the required number will be found on the same line with those three figures, and in that column which has at its head the fourth figure of the given number; the two first figures of the logarithm will be found in the second column (headed 0), and which figures being common to all the logarithms inclosed by each pair of horizontal lines, it is unnecessary to repeat. Where these first figures change their value in the middle of a line, the same is indicated by a break in the horizontal line, thus, 139879 | 0194, which shews that the two first figures (13) have changed to 14, and the right hand logarithm is therefore 140194.

Examples.

Required the logarithm of 734.

In Table I., on the same line with 734 and under 0, are found 5696, the four last figures of the logarithm, to which the *common* figures 86 and the proper characteristic 2 being prefixed, we obtain 2·865696, the logarithm required.

Find the logarithm of 3476.

Here, on the same line with 347 and under 6, will be found 1080, which, with the two first figures and the characteristic prefixed, is 3·541080, the logarithm required.

The log. of 5·84 is 0·766413
„ ·0932 „ $\bar{2}$·969416
„ 10·24 „ 1·010300
„ 3708 „ 3·569140

When the quantity whose logarithm is required contains more than four figures, proceed as follows:—Find the logarithm for the first four figures as above, then look in the first column of the Table of Proportional Parts, at

the lower part of each page, for the first four figures, and on the same line in the column having at its head the fifth figure will be found the quantity which must be added to the logarithm already taken out, to give the logarithm of the quantity first required. If the first four figures are not found in the first column of the table, then take the line containing the next *less* number to it. If the number whose logarithm is required contains more than five figures, proceed as above to obtain the logarithm of the first five figures, then, on the same line of the Table of Proportional Parts that the number added to the logarithm for the fifth figure was found, and in the column having at its head the sixth figure, will be found a quantity which, divided by 10 (or what is the same, having its right hand figure taken away*), and added to the logarithm already found, will give the logarithm of the first six figures; again, on the same line and in the column having at its head the seventh figure, will be found a quantity which, divided by 100 (or having two figures cut off from the right hand), and added, will give the logarithm for seven figures.

Examples.

Required the logarithms of 11488, 621547, 768654, 7642·179.

Log. of the first four figures from Tab. I.	= 4·059942	
From Table of Proportional Parts on line with 1148 and under 8	= 302	4
Logarithm of 11488, as required	= 4·060244	
Log. of 6215	= 5·793441	
From Table of Proportional Parts, on line with 6160, the next less No. in the table to 6215, and under 4	= 28	
On same line under 7	= 4	9
Logarithm of 621547	= 5·793474	
Log. of 7686	= 5·885700	
From Table of Proportional Parts on same line with 7686 and under 5	= 28	
On same line under 4	= 2	2
Logarithm of 768654	= 5·885730	
Log. of 7642	= 3·883207	
From Table of Proportional Parts on same line with 7552 and under 1	= 5	7
On same line under 7	= 3	99
On same line under 9	=	513
Logarithm of 7642·179	= 3·883217	

* If the figure thus cut off exceeds five, one must be added to the last right hand figure left.

To find the number answering to any given logarithm.

Look in the upper portion of Table I. for the given logarithm, or the next less in value to it that can be found, then on the same line, in the first column, will be found the first three figures, and at the head of the column in which the logarithm was found, the fourth figure of the number sought. If the given logarithm is found exactly in the table, the figures thus obtained will be the required number, care being taken to point off one more figure to the left hand than there are units in the characteristic of the given logarithm, cyphers being attached to the right hand of the number, if requisite. If, however, the given logarithm is not found exactly in the table, subtract from it the next less logarithm found, calling the remainder the first difference; then look in the Table of Proportional Parts on the same line with the four figures already obtained from Table I. (or the next less figures which can be found) for this difference, and at the head of the column in which it is found will be the fifth figure of the number sought. If the first difference is not found exactly in the table, look for the next less number to it, which subtract from the first difference for the second difference; then add a cypher to this second difference, and look for it on the same line of the Table of Proportional Parts, as before, and the figure at the head of the column containing the nearest number to it, either greater or less, will be the sixth figure of the number required.

Examples.

Required the number answering to the logarithm 3·241756.

Given log.	= 3·241756	
Next less log. in Table I.	= 3·241546 = the log of	1744·
	210 first dif.	
In Table of Prop. Parts on same line with the next less No. to 1744	199 is found in col. 8	·8
	110 second dif.	
On the same line . . .	99 is found in col. 4	·04
	The No. required =	1744·84

In this example the next less logarithm which can be found in Table I. is 3·241546, the number answering to which, 1744, is the first four figures of the number sought; then subtracting this logarithm from the given logarithm, we obtain for the first difference 210, and looking in the Table of Proportional Parts on a line with 1740 (the next less number to 1744), for the next less number to 210, we find 199, at the head of the column containing which is 8, the fifth figure required; then, subtracting 199 from 210, we obtain the second difference, 11, and adding a cypher, the nearest number which we find on the same line is 99, at the head of the column containing which is 4, the sixth figure required.

Required the numbers answering to the following logarithms: 3·510009, 2·475771, 5·871624.

The number answering to the logarithm 3·510009 is found at once to be 3236.

Given log. = 2·475771		
Next less log. = 2·475671 = the log. of 299·0		
	100 = 1st dif.	
From Table of Proportional Parts	87	·06
	130 = 2nd dif.	
	130	·009
	No. required =	299·069

Given log. = 5·871624		
Next less log. = 5·871573 = the log. of 744000·		
	51 = 1st dif.	
From Table of proportional parts	46	
		80·
	50	
	52	9·
	The No. required =	744089·

It should be observed here, that the number of figures which may be depended upon in any result obtained by logarithms, will be equal to the number of decimal places in the logarithms employed; thus, in using the tables appended to this work, the results obtained will be accurate to six figures, except towards the end of the tables, in which only five figures should be trusted.

Mathematical Tables.

Tables III., IV., and V.

Mathematicians have computed the lengths of the sines, tangents, and secants (assuming unity for the radius) corresponding to arcs from 1 minute of a degree, through all the gradations of magnitude, up to a quadrant, or 90°; and the results of the computations are arranged for use in tables called *Trigonometrical Tables*. As, however, these quantities have to be carried to several places of decimals in order to obtain sufficiently accurate results, their use in calculations is attended with much labour, and therefore it is usual to employ their logarithms instead; but in this case the assumed radius is taken as 10,000,000,000 instead of unity, since with the latter most of the quantities would be *fractional*, and therefore

have *negative* characteristics, the use of which would be inconvenient, and is superseded by taking the radius as above.

Table V. is such a table of the logarithms of the sines, cosines, tangents, cotangents, secants, and cosecants, for every minute from 1 minute to 90 degrees, calculated to a radius of 10,000,000,000 as above. It will be observed that the headings of the columns run along the *tops* of the pages as far as the 45th degree, after which they return along the *bottoms* of the pages in contrary order, as below :—

Sin	D.	Cosec	Tan	D.	Cot	Sec	D.	Cos
Cos	D.	Sec	Cot	D.	Tan	Cosec	D.	Sin

The reason of this will be apparent, if we only consider that the cos, cot, or cosec of an arc is the sin, tan, or sec of the *complement* of that arc. The intermediate columns headed D, contain the differences of the consecutive logarithms in the contiguous columns on either side; it will be seen that the same difference is common to the sin and cosec, the tan and cot, and the sec and cos; since, from Table XXI.,

$$\sin = \frac{1}{\text{cosec}}, \text{ or } 1 = \sin \,.\, \text{cosec}; \quad \tan = \frac{1}{\cot}, \text{ or } 1 = \tan \,.\, \cot;$$

$$\sec = \frac{1}{\cos}, \text{ or } 1 = \sec \,.\, \cos; \text{ and consequently, } \log \sin + \log \text{cosec} = \log \tan + \log \cot = \log \sec + \log \cos = 2 \log \text{rad} = 20\cdot;$$

therefore as the sin, tan, or sec increases, so must the corresponding cosec, cot, or cos diminish, and their differences must be equal. The differences of the sines and tangents are not inserted on the two first pages, for the reason explained at page 21.

USE OF TABLE V.

To find the logarithmic sine, tangent, &c., of a given arc.

If the arc contains only degrees and minutes, its sin, tan, &c., will be found simply by inspection, by looking along the top or *bottom* of the tables for the degrees, and then in the first or *last* vertical column for the minutes, according as the number of degrees is less or *greater* than 45°; and on the same line, in the column having for its title (either at the top or *bottom*, according as the degrees were found) the name of the trigonometrical quantity required, its log will be found.

If the arc contains seconds as well, the logarithm must be found as above for the degrees and minutes; then take the number in the contiguous column headed D on the same line, multiply it by the number of seconds, and divide by 100 (which is done by cutting off the two last figures); the quotient must then be added to or *subtracted* from the log

already taken out, according as the same would be increased or *decreased* by an increase in the arc.

Examples.

1. Find the log sin of 37° 47′.

As the arc is *less* than 45°, by looking along the *top* of the table for the degrees, and in the *first* column for the minutes, we find in the column having at its *top* the word sine the figures 9·787232, which is the log sine of the arc required.

2. Find the log tan of 75° 34′.

Here, as the arc is *greater* than 45°, looking at the *bottom* of the tables for the degrees, and in the *last* column for the minutes, we find in the column having tan at the *bottom*, 10·589431, the tan of 75° 34′.

3. Find the log sin of 31° 45′ 5″.

The log sin of 31° 45′ is	9·721162
The No. in col. D is 340 × 5″ ÷ 100 = + . . .	17
∴ The log sin of 31° 45′ 5″ = ...	9·721179

4. Find the log cos of 25° 1′ 47″.

The log cos of 25° 1′ is	9·957217
The No. in col. D is 98 × 47″ ÷ 100 = −	47
∴ The log cos of 25° 1′ 47″ = ...	9·957170

To find the arc corresponding to any given log sin, tan, &c. :—

Look in Table V. for the given log sin, &c., or the next less log thereto, and on the same line will be found the minutes, and at the top or bottom of the page the degrees, of the arc required; if the log thus found is less than the given log, subtract the former from the latter, add two cyphers to the right of the remainder, and divide it by the number found in the contiguous column headed D; the quotient will be the number of seconds to be added to the degrees and minutes in the arc already obtained.

Examples.

1. Find the arc whose log tan is 10·577537.

Here the arc is found by inspection to be 75° 11′.

2. Find the arc corresponding to the log sin 9·395401.

Given log = 9·395401
Next less log = 9·395166 = log tan 14° 23′

23500 ÷ 820 = 29 seconds;

∴ 9·395401 is the log tan of 14° 23′ 29″.

In the sines and tangents of arcs less than about 5°, the differences between any two successive values are so great (as will be seen by an inspection of column D in the table) that the method above given for finding the intermediate values for seconds will not be sufficiently correct; and the same remark applies to the cosines and tangents of arcs greater than about 85°. It will also be observed, that in the cosines and secants of arcs less than 5°, and in the sines and cosecants of arcs greater than 85°, the differences are too small to enable us to calculate accurately the value of any arc from them.

The first of these difficulties may be removed by the rules given below for determining the values of the sines and tangents of small arcs, and the tangents of large arcs, and conversely the arcs from the sines and tangents. A table has also been given (Table IV.) of the logarithmic sines for every tenth of a minute as far as a degree and a half, and of the cosines for every tenth of a minute from 88° 29′ to the end of the quadrant. The second difficulty, however, could only be got over by extending the tables to more decimal places, but as this would also require all other quantities employed in the same calculations to be taken to an equal number of decimals, much additional trouble would be occasioned; and it is therefore better for determining the value of an arc when near 90°, to employ some other function than its sine, as, for instance, its cosine. In order to render this clearer to those who are not familiar with the use of logarithms, we subjoin an example of such a substitution of the cosine for the sine.

For instance, let it be desired from the formula.

$$P_1 : P_2 :: \sin \beta : \sin \delta$$

to determine the value of the angle δ, when $P_1 = 600{\cdot}1$; $P_2 = 669$; and the angle $\beta = 63° 45'$.

First by multiplying the means and extremes, and dividing both sides by P_1, we obtain

$$\sin \delta = \frac{P_2 \sin \beta}{P_1} \quad . \quad . \quad . \quad . \quad . \quad . \quad (a.)$$

Then from Table XXI.

$$\sin \delta = \sqrt{1 - (\cos \delta)^2}$$

$$\therefore \frac{P_2 \sin \beta}{P_1} = \sqrt{1 - (\cos \delta)^2};$$

squaring both sides

$$\left(\frac{P_2 \sin \beta}{P_1}\right)^2 = 1 - (\cos \delta)^2,$$

transposing, and extracting the square root.

$$\cos \delta = \sqrt{1 - \left(\frac{P_2 \sin \beta}{P_1}\right)^2} \quad . \quad . \quad (b.)$$

We have, therefore, two equations, (a) and (b), from either of which we can obtain the value of the angle δ, by substituting the values of the known quantities; but in doing so we shall find that the second equation will give the value of δ much more exactly than the first.

Thus, by substituting the known quantities in equation (a), we have

$$\frac{669 \times \sin 63^\circ\ 45'}{600{\cdot}1} = \sin \delta.$$

Whence by logarithms,

Log sin 63° 45′	=	9·952731
Log 669	=	2·825426
		12·778157
Log 600·1	=	2·778224
Log sin δ	=	9·999933

$$\therefore \delta = 88^\circ\ 59'\ 25''.$$

Proceeding in a similar manner with equation (b), we have

$$\sqrt{1 - \left(\frac{669 \times \sin 63^\circ\ 45'}{600{\cdot}1}\right)^2} = \cos \delta.$$

Whence by logarithms, taking the radius as unity, for the reasons explained at page 25.

Log sin 63° 45′	=	$\bar{1}$·952731
Log 669	=	2·825426
		2·778157
Log 600·1	=	2·778224
		$\bar{1}$·999933
		2
Log ·99969	=	$\bar{1}$·999866

Then 1 — ·99969 = ·00031, the log of which = $\bar{4}$·491362, and

$$\bar{4}{\cdot}491362 \div 2 = \bar{2}{\cdot}245681 = \cos \delta;$$

or restoring the radius of the tables,

$$\cos \delta = 8{\cdot}245681 = \text{sin of the complement of } \delta;$$

therefore, by the rule given below for finding a small arc from its sin, we have

8·245681
5·314425
22

3·560128 = 3631·86 seconds = 1° 0′ 31″·86;

$$\therefore \delta = 88^\circ\ 59'\ 28''{\cdot}14,$$

whence we see that the former value of δ obtained from equation (a) is upwards of three seconds too small.

To find accurately the log sin of an arc less than 5°.

Reduce the arc to seconds, and find the log of that number from Table I., to which add 4·685575 (the log sin of 1″), and subtract one-third of the decimal portion of the log sec of the arc taken from Table V.; the remainder is the log sin of the arc required.

Examples.

Find the log sines of 13′ and of 1° 3′.

Log (13′ × 60) = 780″ = 2·892095
4·685575
7·577670
Log sec of 13′ = ·000003 ÷ 3 = ·000001
Log sin of 13′ = 7·577669

Log (63′ × 60) = 3780″ = 3·577492
4·685575
8·263067
Log sec of 1° 3′ = ·000073 ÷ 3 = ·000024
Log sin of 1° 3′ = 8·263043

To find accurately the log tan of an arc less than 5°.

To the log of the number of seconds in the arc add 4·685575, and two-thirds of the decimal portion of its log sec; the sum is the log tan of the arc required.

Examples.

Find the log tans of 24′ and 1° 15′.

Log (24′ × 60) = 1440″ = 3·158362
4·685575
Log sec of 24′ = ·000011 × ⅔ = ·000007
Log tan of 24′ = 7·843944

Log (75′ × 60) = 4500″ = 3·653213
4·685575
Log sec of 1° 15′ = ·000103 × ⅔ = ·000068
Log tan of 1° 15′ = 8 338856

To find accurately the log tan of an arc greater than about 85°.

Add to the log of the number of seconds that the arc is less than 90°, two-thirds of the decimal portion of the log cosec, and subtract the sum from 15·314425; the remainder will be the log tan required.

Examples.

1. Find the log tan of 89° 5′ 13″.

90° 0′ 0″
89 5 13

0° 54′ 47″ = 3287 seconds.

Constant log = 15·314425
Log of 3287 = 3·516800
Log cosec of 89° 5′ 13″ = ·000057 × $\frac{2}{3}$ = ·000038
3·516838

Log tan of 89° 5′ 13″ = 11·797587

2. Find the log tan of 88° 51′ 10″.

90° 0′ 0″
88 51 10

1° 8′ 50″ = 4130 seconds.

Constant log = 15·314425
Log of 4130 = 3·615950
Log cosec of 88° 51′ 10″ = ·000087 × $\frac{2}{3}$ = ·000058
3·616008

Log tan of 88° 51′ 10″ = 11·698417

To find accurately an arc of not more than 5° *from its log sine.*

To the given log sin, add 5·314425, and one-third of the decimal portion of the secant of the nearest arc to that whose log sin is given, the sum, rejecting 10 from the characteristic, will be the logarithm of the number of seconds in the arc.

Example.

Required the arc whose log sin is 8·314719.

Given log sin = 8·314719
Constant log = 5·314425
Log sec of nearest arc = ·000093 ÷ 3 = ·000031

Arc required 1° 10′ 58″ = 4258″ = 3·629175

To find accurately an arc of not more than 5° from its log tan.

To the given log tan add 5·314425, and from the sum subtract two-thirds of the decimal portion of the log sec of the arc whose log tan is nearest to that given, and the remainder, rejecting 10 from the characteristic, will be the log of the number of seconds in the arc.

Example.

Required the arc whose long tan is 8·231461

Given log tan	=	8·231461
Constant log	=	5·314425
		13·545886
Log sec of nearest arc = ·000063 × $\frac{2}{3}$. .	=	·000042
Required arc = 58′ 34″ = 3514″ . .	=	13·545844

To find accurately an arc greater than 85° from its log tan.

Add to the given log tan two-thirds of the decimal portion of the log cosec of the nearest arc to that whose log tan is given, and subtract the sum from 15·314425; the remainder is the log of the number of seconds that the arc is *less than* 90°.

Example.

Required the arc whose log tan is 11·695900.

Constant log		=	15·314425
Given log tan	=	11·695900	
Log cosec of nearest arc ·000088 × $\frac{2}{3}$ =		·000059	
			11·695959
Required arc = 1° 9′ 14″ = 4154″ . . .		=	3·618466

In extracting the root or raising the power of any trigonometrical quantity by means of its logarithm, it will always be found most convenient to reduce the assumed radius to unity, by subtracting 10 from the characteristic of the logarithm, which will frequently then become *negative*; it must, however, be borne in mind that the *decimal* part of the logarithm is always *positive*; and, therefore, if it is required to multiply a logarithm with a negative characteristic by any number (as the index of a power), first multiply the decimal part of the logarithm, pointing off as many decimal figures in the product as there were in the logarithm, then multiply the characteristic, and subtract from the product the number (if any) pointed off to the *left* in the first product: the result will be the negative characteristic, and the decimals pointed off in the first product will be the decimal part of the required logarithm. To divide a logarithm with a negative characteristic by any number: if the characteristic is a

mutiple of that number, that is, if it is *divisible* by it without remainder, proceed as in ordinary division; if not, separate the characteristic from the decimal, and add to the characteristic a number which will make it *divisible*, and prefix to the decimal the same number, then divide both by the given divisor, and the quotients will be the characteristic and decimal of the logarithm required. An example of this alteration of the characteristic is given at page 22.

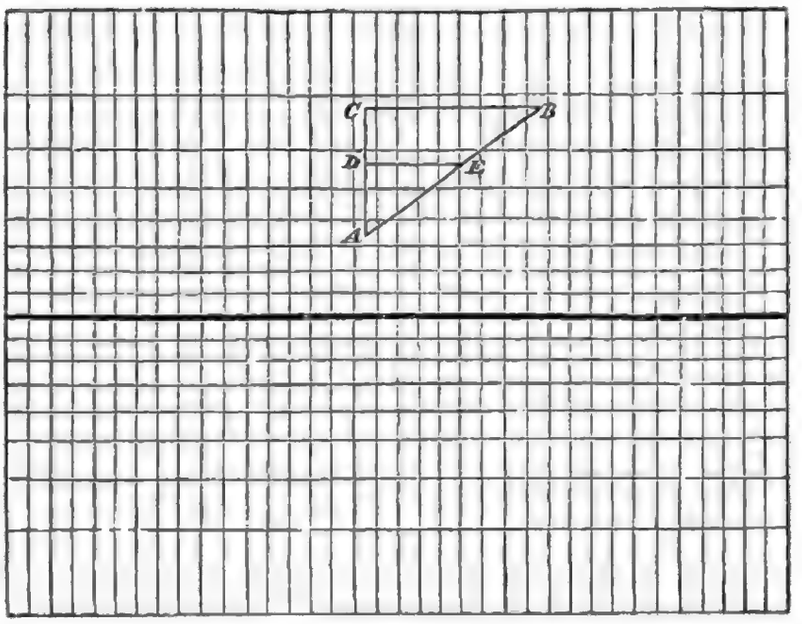
Although Table V. only purports to give the sines, tangents, &c., of angles less than, or equal to 90°, any of these functions of angles *greater* than 90° may readily be obtained, since any function of an angle greater than 90° is equal to the same function of the *supplement* of that angle; due regard being had to changing the sign, if requisite, according to Table III., which exhibits the value of each trigonometrical line at the commencement of each quadrant, and also the sign with which it is effected in passing through the same. Thus, the *log sin* of 141° 15′ is 9·796521, the same as the *sin* of its supplement 38° 45′; the *log sec* of 95° 43′ is — 11·001701, or the *sec* of 84° 17′ with its sign changed; the *log cosec* of the same is 10·002165, or the *cosec* of 84° 17′, the sign remaining the same; and the *log tan* of 173° 4′ is — 9·084947, or the *tan* of 6° 56′ with its sign altered.

Table VI.

Meridional Parts.

In nautical charts, drawn according to Mercator's projection of the sphere, the meridional lines are drawn parallel to each other, or equidistant in every latitude, as shewn in fig. 1, so that the distance between any two meridians being assumed as true at the equator would be too great in every other latitude; for whereas the length of a degree of latitude really decreases as we approach the poles, here it is represented as though its length were everywhere the same. If, therefore, the parallels of latitude were drawn at equal distances in representing any country situated in a high latitude, its form would become so much distorted from its breadth being thus increased without its length, that the country would hardly be recognised, and very erroneous views would be occasioned of its form and relative extent. Thus, in the latitude of 60°, a degree of longitude is only half what it is at the equator, and therefore all dimensions east and west would be twice as great as they should be, if drawn to the same scale as those north and south. To correct this distortion, therefore, and preserve the true form of the countries, the distance between the parallels of latitude is increased precisely in the same proportion as that between the meridians; so that on a Mercator's chart the relative magnitude of a degree of latitude and longitude is everywhere truly preserved; the parallels of latitude being drawn more and more distant as we leave the equator, as shewn in fig. 1.

Fig. 1.



Now, the numbers in the table of meridional parts are nothing more than the distances of the several parallels of latitude from the equator, as shewn on a Mercator's chart, expressed in minutes* of longitude at the equator. In using the table the degrees of latitude must be sought at the top of the table, and the minutes in the side column, the meridional parts will then be found at their intersection; thus the meridional parts of 27° 25′ are 1712, and of 76° 3′ are 7222.

The great use of this table for nautical purposes is to determine the latitude and longitude of a ship at sea, when the course and distance that she has run are known. By the *course* of a ship is meant the direction in which she sails, estimated by the angle which that direction makes with the meridian. When the course makes the same angle with every meridian crossed, it is termed a *rhumb*, and this course is that usually adopted by navigators, in consequence of the facilities which it affords in ascertaining the position of their vessels.

On a Mercator's chart any rhumb is obviously a straight line, because no other than a straight line would on such a chart cross every meridian at the same angle. Thus, if A and B, figure 1, are any two places between which a vessel sails, then the straight line A B is the rhumb upon which the vessel would sail to preserve the same course or make the same angle with every meridian crossed; A C is the difference of latitude, C B the difference of longitude, and A B the *nautical distance* run. If now we set off from A towards C, a distance A D equal to the actual difference of latitude measured in degrees at the equator, and draw a line D E parallel to the equator, then will the line A E, measured on the equator, be the true nautical distance, and, being multiplied by 60 (the number of nautical

* It is hardly necessary to state that a minute is the 60th part of a degree, and a second the 60th part of a minute.

miles in a degree), will give the distance run by the ship, and the line D E is termed the *departure* or distance run either to the east or west.

By inspecting the diagram, we see that A E : rad : : A D : cos < A, or the nautical distance is to radius as the actual difference of latitude is to the cosine of the course; and also A B : rad : : B C : tan < A, or the meridional difference of latitude is to radius as the difference of longitude is to the tangent of the course.

If we put d for the nautical distance, c for the course, l for the difference of the latitude, λ for the meridional difference of latitude, and L for the difference of longitude, we have, from the above proportions,

$$\text{rad} \cdot l = d \cos c,$$
$$\text{And rad} \cdot \mathrm{L} = \lambda \tan c.$$

From which formulæ either two of the four quantities d, c, l, and L being known, the others may be easily found.

For example, a vessel leaving latitude 25° 34′ N. and longitude 61° 24′ W. sails 543 nautical miles on a rhumb line, whose course is N. 42° 5′ E., what latitude and longitude is she then in?

Log cos c (= 42° 5′) =	9·870504
Log d (= 543) . =	2·734800
	12·605304
Rad =	10·000000
	2·605304 = log of 403 = l,

then 403 ÷ 60 = 6° 43′ = the ship's difference of latitude to the north; therefore, 25° 34′ + 6° 43′ = 32° 17′ N. is the latitude she is now in. Again,

Meridional parts for 32° 17′ =	2048
,, ,, for 25 34 =	1588
Meridional difference of latitude = λ =	560

Log tan c (= 42° 5′) =	9·955707
Log λ (= 560) . =	2·748188
	12·703895
Rad =	10·000000
	2·703895 = log of 505·7 = L,

then 505·7 ÷ 60 = 8° 25′ 42″ = the ship's difference of longitude to the east; therefore, 61° 24′ − 8° 25′ 42″ = 52° 58′ 28″ W. is the longitude she is now in.

Example 2.—A vessel sails from latitude 41° 20′ N., and longitude 49° 50′ W., to latitude 64° 25′ N., and longitude 10° 13′ 6″ W., what was her course and nautical distance?

Meridional parts for 64° 25′ = 5097
„ „ for 41 20 = 2728

23 5 2369 = λ = Meridional difference of latitude.
60

Difference of lat. = l = 1385

49° 50′ 0″
10 13 6

39 36 54
60

Log L (= 2376·9) . . = 3·376010
Rad = 10·000000

13·376010
Log λ (= 2369) . . . = 3·374565

10·001445 = log tan 45° 5′ 44″ = c.

Log l (= 1385) . . . = 3·141450
Rad = 10·000000

13·141450
Log cos c (= 45° 5′ 44″) = 9·848757

3·292693 = log of 1962 = d.

Table VII.

Length of a Degree of Longitude on each Parallel of Latitude.

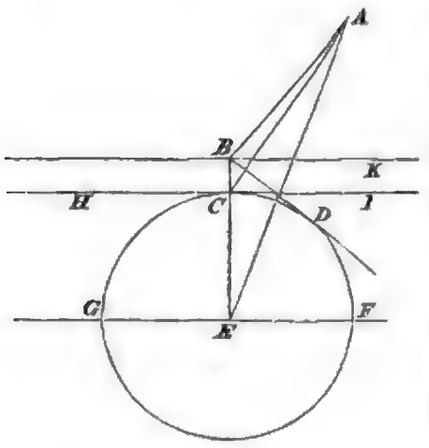
This table requires no explanation; it exhibits the length of a degree of Longitude in nautical miles (each of which equals 6075·6 feet) at every degree of latitude from the Equator to the Poles.

Tables VIII. and IX.

Dip of the Horizon.

The latitude and longitude of a vessel is determined by observations made on the heavenly bodies, which observations consist principally in measuring their altitudes or the angle which they make with the horizon. The altitudes thus taken being compared with certain altitudes given in

the "Nautical Almanac," enable the observer to determine both his latitude and longitude. It is, however, requisite to make certain corrections in the observed altitudes in order to obtain the true altitudes.



If, in fig. 2, G C D F is a section of the earth, and B the place of an observer, then G E F is the *rational horizon*, and H C I the *sensible horizon*. Also, if A is the place of a heavenly body, the angle A E F is its *true altitude*, A C I its *apparent altitude*, and A B D its *observed altitude*.

If the observer had been on the surface of the earth as C, then the *observed* altitude would have coincided with the *apparent* altitude, but when raised above the same, as is always the case at sea when the observations are made from the vessel's deck, the horizon *dips*, or becomes depressed, as shewn by the line B D, and the *observed* altitude A B D becomes greater than the apparent altitude A B K or A C I* by the angle K B D: the magnitude of this angle (termed the *dip of the horizon*) depends upon the height of the observer above the surface of the earth; its values for all heights between 1 and 140 feet are given in Table VIII. The angle found in the second column must be *subtracted* from the *observed* altitude to obtain the *apparent* altitude.

The dip given in Table VIII. supposes that the view of the sea horizon is perfectly unobstructed. Should, however, any object intervene, as a coast, the margin of the sea where it meets the shore must then be taken as the horizon; and in this case the angle to be *subtracted* from the *observed* altitude will be found in Table IX. under the proper height, and on a line with the distance of the object from the observer, which may always be judged of with sufficient precision by an experienced eye. Thus, if the vessel is about 2 miles from the shore and the observer is 20 feet above the surface of the sea, the angle to be subtracted for the dip will be 6 minutes.

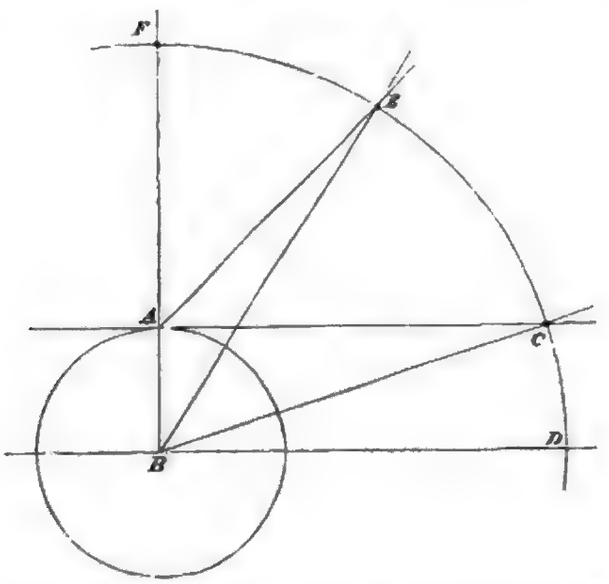
Table X.

Reduction of the Moon's Horizontal Parallax.

The difference between the *apparent* altitude of a heavenly body, or the angle which it makes with the *sensible* horizon, and its *true* altitude, or the angle which it forms with the *rational* horizon, is termed its *parallax*. The parallax of a body is greatest when it is in the horizon, and it decreases as its altitude increases, until, when it attains the zenith,

* The distance B C of the observer above the earth's surface is so inconsiderable, as compared with B A, the distance of the body, that these two angles may be considered as equal without any appreciable error.

its parallax becomes nothing. Thus, in fig. 3 the parallax at C is greater than that at E, and is nothing at the zenith F.



The amount of the horizontal parallax depends upon the distance of the body A C and upon the earth's radius A B. The nearer the object, that is, the less A C is, the greater is the angle A C B or the parallax. The moon being much nearer to the earth than any other of the heavenly bodies, its parallax is much greater, and as its distance from the earth varies, so also does its parallax; the amount of its parallax is given in the "Nautical Almanac" for every day throughout the year. The parallax there given is, however, calculated for the earth's greatest or equatorial radius; and since, from the proximity of the moon, the decrease of the earth's radius in higher latitudes diminishes the parallax to such an extent as to require correction, we have given in Table X. the amount to be *subtracted* from the equatorial parallax to give the true parallax in any given latitude. For example, let the earth's equatorial parallax on any given day, as found in the "Nautical Almanac," be 58 minutes, what will it be for the same day in latitude 52°? Here under 58′, and on a line with 52°, we find 7·″2, which must be subtracted from 58′, giving 57′ 52·″8 for the moon's parallax in that latitude.

Table XI.

Augmentation of the Moon's Semidiameter.

In making an observation, it is the position of the *centre* of the object which is required, but as it would not be easy in practice to judge with sufficient precision of its position, it is usual to measure to the nearest edge (or *limb*, as it is termed) of the object, and to add the angular value of its semidiameter. In the case of the moon, its apparent semidiameter varies considerably according to its distance from the earth, and also from its great proximity its semidiameter is sensibly increased by the parallax; for, as her altitude increases, she approaches nearer to the observer, and the apparent semidiameter becomes greater. The value of her *horizontal*

semidiameter for every day is given in the "Nautical Almanac;" and Table XI. shews the augmentation of the same occasioned by an increased altitude. Thus, when the moon's *horizontal* semidiameter is 15′ 30″, her *apparent* semidiameter, with an altitude of 51°, will be 15′ 42″.

Table XII. and XIII.

Longitude and Time.

As the sun apparently revolves round the earth once in every twenty-four hours, with an equal rate, it arrives at each meridian at a different time. And it is on this principle that the longitude of a place is determined by the interval of time between the sun's passing the meridian of that place and the meridian of Greenwich. As the whole 360° are equal to an interval of 24 hours, any lesser number of degrees are equal to a proportionate interval of time, and these two tables are for facilitating the conversion of longitude into time, or *vice versâ*. As an example of their use, let it be required to find the interval of time corresponding with a difference of longitude of 43° 13′ 10″.

					h.	m.	s.
From	2nd	column,	Table	XII. 40° =	2	40	
„	1st	„	„	3° =		12	
„	1st	„	„	10′ =		40	
„	1st	„	„	3′ =		12	
„	3rd	„	„	10″ =			0·667
				The time is therefore .	2	52	52·667

Again, if it were required to know the difference of longitude corresponding with an interval of 4 hours, 31 minutes, and 6 seconds; we have

From	1st	column	of	Table	XIII.	4 hours =	60°	0′ 0″
„	2nd	„		„	„	30 mins. =	7	30 0
„	2nd	„		„	„	1 min. =	0	15 0
„	2nd	„		„	„	6 secs. =	0	1 30
						Which gives for the diff. of longitude .	67	46 30

Table XIV.

Parallax in altitude of the Sun and Planets.

The *horizontal* parallax of the sun and planets depends upon their distance from the earth, and is given for every day in the "Nautical Almanac." The parallax for any altitude is, as already explained, less than when the object is in the horizon; and Table XIV. is intended to give the amount of parallax for any apparent altitude when the amount of the horizontal parallax is known. In using the Table look for the *horizontal* parallax at the head of the Table, and in the column at the head of which it stands,

and on the same line with the *apparent* altitude, will be found the parallax required. For example, if the sun's horizontal parallax is 9″, what is her parallax with an apparent altitude of 48°? Here, in the column having 9″ at its head, and on the same line with 48°, will be found 6″, which is the sun's parallax at the time.

Tables XV. and XVI.

Refraction of the Sun and Stars.

There is another correction rendered necessary in order to reduce the *observed* altitude of a heavenly body to its *apparent* altitude; in consequence of the optical property of the atmosphere termed refraction. While the effect of the parallax is to make the object appear lower than its true place, that of refraction is to make its altitude appear greater. The effect of refraction is greatest when the object is in the horizon, and it gradually diminishes until at the zenith it becomes nothing; it is not, however, always constant for the same altitude, but varies with the temperature and density of the atmosphere. Table XV. gives the refraction for every ten minutes of apparent altitude, calculated for a mean temperature of 50° Fahr., and a mean pressure of 29·6 ins.; and Table XVI. contains the correction requisite to be made for any other temperature and pressure. For example, what is the refraction of any heavenly body whose observed altitude is 31° 20′ when the temperature is 72°, and the barometer 30·35? In this case we first find, from Table XV., the refraction for a mean state of the atmosphere to be 1′ 35·5″, we then find, from Table XVI., that at the temperature of 72° we must *subtract* 5″, and with the barometer at 30·35, that we must *add* 1″, after which we have 1′ 31·5″ for the required refraction. It must be observed, that when the temperature is *below* the mean, the correction must be *added*, and when *above*, the mean *subtracted;* also, when the barometer is *below* the mean the correction must be *subtracted*, but when *above* the same it must be *added*. The correction for the thermometer is found in the column having the temperature at its head, while that for the barometer is found in that having the pressure at its foot.

Table XVII.

Correction of the Moon's Altitude.

As already explained, the effect of the refraction is to raise the object, while that of parallax is to depress it; the parallax, however, being always the greater, the *apparent* altitude is always less than the *true* altitude. Table XVII. contains the difference of the refraction and parallax for the moon, which is therefore the correction to be *added* to the *apparent* altitude to obtain her *true* altitude. In using the table, the correction will be found in the column having at its head the moon's horizontal parallax, and opposite to the apparent altitude. Should these not be found exactly in the table, we must take the next less values, and to the number thus found we must add or subtract (as the case may be) a pro-

portional part for the requisite number of minutes or seconds wanting, which are given for the altitudes in the left-hand column, and for the parallax in the right-hand column. For example, let the correction be required when the apparent altitude is 29° 37′, and the moon's horizontal parallax is 56′ 24″. In this case the next less numbers to these in the Table are 29° 30′ and 56′.

Under 56′, and opposite 29° 30′, we find		47′	1″
Add proportional parts for parallax	20″		18
„ „ „ „ „	4″		3·5
		47	22·5
Subtract prop. parts for altitude	7′		3
Correction required . . .		47	19·5

The moon's true altitude therefore equals 30° 24′ 19″·5.

Ex. 2. What is the moon's true altitude when its apparent altitude is 9° 53′, and its horizontal parallax is 58′ 20″?

Under 58′ and opposite 9° 50′ we find .		51′	44″
Add proportional parts for parallax	20″		20
„ „ „ for altitude	3′		2
Correction		52	6

Therefore the moon's true altitude equals 10° 45′ 6″.

Table XVIII.

Logarithms for finding the Horary Angle or Apparent Time.

The use of this Table is to facilitate the calculation of the Apparent Time at any place, from observations made on the altitude of some known celestial body. The logarithms in the Table are twice the sine of half the arc of longitude corresponding with the number of hours and minutes at which it stands*. The use of the Table is as follows:—having obtained this logarithm, look in the table for it, or for the next less logarithm to it, and take out the time in hours and minutes as found (if the altitude is *decreasing*) at the top and in the left-hand column, (but if *increasing*) at the bottom, and in the right-hand column. Then subtract the logarithm taken in the table from the given logarithm, and having added to the right of the difference thus obtained two cyphers, divide it by the nearest number in the contiguous column headed *Diff.*, and the quotient will be the number of seconds to be *added* to the hours and minutes already obtained, when the altitude is *decreasing*, and to be *subtracted* when *increasing*. For example, what is the apparent

* The manner of performing the calculation by which this logarithm is derived from the observed altitude is fully explained in a *Treatise on Navigation*, by James Greenwood, B.A.—Weale, Holborn.

time corresponding to the logarithm 9·649321 when the altitude was decreasing?

Given log 9·649321
Next less log in Table 9·648913 = log of 5 H. 35 M.

40800 ÷ 3516 = 11 seconds.

Therefore, the apparent time required is 5 H. 35 M. 11 S.

Ex. 2. What is the apparent time corresponding with the logarithm 9·215630, when the altitude was increasing?

Given log 9·215630
Next less log in table 9·214358 = 20 H. 49 M.

127200 ÷ 7114 = 18 seconds.

Therefore the apparent time is 20 H. 48 M. 42 S.

TABLE XIX.

Common and Hyperbolic Logarithms.

The object of this Table is to facilitate the conversion of common logarithms, into hyperbolic, and *vice versâ*. Its use is as follows:—To convert common logarithms into hyperbolic, write the common logarithm, as shewn in the first example below, and then take from the second column of the Table the equivalent value of each figure in hyperbolic logarithms, taking care that the latter are each moved as many places to the right as the corresponding numbers in the common logarithm are; the sum of the whole will be the hyperbolic logarithm required.

To convert hyperbolic logarithms into common, proceed in a similar manner, writing the hyperbolic logarithm as in the second example below, and taking its equivalent value in common logarithms from the fourth column of the Table.

Ex. 1. What is the hyperbolic logarithm of 3156?

By reference to Table I. we find the common logarithm of 3156 is 3·499137; then—

Com. Log.		Hyp. Log.	
3·	=	6·907755	3
·4	=	·921034	0
·09	=	·207232	7
·009	=	·020723	3
·0001	=	·000230	3
·00003	=	·000069	1
·000007	=	·000016	1
		8·057061	

Ex. 2. What is the common logarithm of the number whose hyperbolic logarithm is 5·160731?

Hyp. Log.		Com. Log.	
5·	=	2·171472	4
·1	=	·043429	5
·06	=	·026057	7
·0007	=	·000304	0
·00003 . . .	=	·000013	0
·000001 . . .	=	·000000	4
		2·241277	

Table XX.

Curvature of the Earth and Refraction.

This table is of use in Geodesical operations. Practically, a level line on the earth's surface is a line everywhere equally distant from its centre. It is obviously, therefore, not a straight line, but is a portion of a circle, having the same radius as the earth. When a level, theodolite, or other instrument has the axis of its telescope so adjusted as to be truly level, the prolongation of that axis is not a level line, but is a tangent to that line, coinciding with it only at the point where the instrument stands, and being *above* it everywhere else. The height of this line above the true level line, if there were no refraction, would be equal to the ver sine of an arc whose radius equalled that of the earth, and whose length was equal to the distance from the instrument: these heights for various distances up to 30 miles are given in the second column of the Table. The effect, however, of the refraction of the atmosphere is to curve the visual ray passing through the centre or axis of the telescope, so that the optical axis is really a curved line which approximates very nearly to a circle, having a radius seven times greater than that of the earth. The heights in the second column require to be reduced by a seventh part, and the numbers thus obtained are given in the third column. To exemplify its use, let us suppose that an instrument, placed in an elevated position, has its telescope directed to a church tower 3 miles distant, and that when its telescope is perfectly level the horizontal wires are found to cut a point in one of the windows, which, on direct measurement, is found to be 95 feet from the ground, it is required to ascertain the real difference of level of the two spots. Now, on reference to the Table, we find the correction for 3 miles is 5·14, which, being *subtracted* from 95 feet, gives 89·86 feet for the actual height of the instrument above the ground on which the tower stands. In taking a series of consecutive observations, as in the ordinary operation of levelling by *back* and *fore* sights, to ascertain the relative level of two distant places, so long as no great difference in the range or length of the sights occurs, no correction for curvature or refraction need be made, for when the sights are actually equal no error arises in the ultimate result.

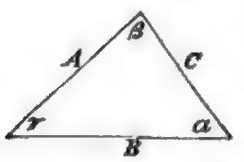
Tables XXI., XXII., XXIII., and XXIV.

Trigonometrical Expressions.

These Tables require no particular explanation. Table XXI. contains equivalent expressions for *sin a, cos a, tan a, cot a, sec a, cosec a, ver sin a,* and will be found of considerable use in reducing formulæ containing trigonometrical expressions. Table XXII. contains expressions, the sin, cos, tan, and cot, of mutiple arcs. Table XXIII. contains a variety of formulæ relating to the trigonometrical functions of two angles or arcs. And Table XXIV. contains expressions for the sin, cos, tan, and cot, in terms of the arc, and for the arc in terms of the sin and tan, and also expressions for the powers of the sin and cos.

Table XXV.

Fig. 4.



The formulæ given in this Table are intended to enable all the six parts of a plane rectilineal triangle to be determined when three of those parts were previously known. When either a side or angle is wanted it will only be necessary to make A or β the side or angle as the case may be, and to insert in the formulæ the proper values of those letters which are known, which will then express the value wanted. For example, in a triangle, two of whose sides are 23 and 35 feet in length, and the angle included between is 51°, what is the length of the third side? In this case we have given B, C and *a*, and want to find A, we must, therefore, select a formulæ containing only those letters; we find, accordingly, No. 7 gives

$$A = \sqrt{(B^2 + C^2 - 2\,B\,.\,C\,.\,\cos a.)}$$

We have B = 23, C = 35, cos 51° = ·62932; inserting these values, we have

$A = \sqrt{(23^2 + 35^2 - 2 \times 23 \times 35 \times \cdot62932)} = 27\cdot217$, which is the length of the side required.

Table XXVI.

The formulæ given in this Table are to facilitate the solution of quadratic and cubic equations, in order to which it is only necessary to substitute for p and q their known values in the formulæ when the value of x will be determined. By way of example, let it be required to find the value of x in the cubic equation $x^3 + 3x - 536 = 0$. We see by reference to the Table that this corresponds with equation (6) in the Table, p being equal to 3, and q to 536. Then, if we substitute these values in the second expression, it becomes.

$$\text{Tan } a = \frac{3}{3 \times 536}\, 2\sqrt{\frac{3}{3}} = \frac{2}{536}$$

therefore, $a = 0^\circ\ 12'\ 36''$, and $\frac{1}{2}a = 0^\circ\ 6'\ 18''$;

then,

$$\text{Tan } \beta = \sqrt[3]{} \tan (6' 18'');$$
$$\text{therefore, } \beta = 7^\circ\ 1'\ 5'', \text{ and } 2\beta = 14^\circ\ 2'\ 10'',$$

and

$$x = 2\sqrt{\frac{3}{3}} \cdot \cot (14^\circ\ 2'\ 10'') = 8,$$

which is the true value of x.

Table XXVII.

This Table contains the differential coefficients of some of the most frequently-occurring functions of u, and will be found to include all the rules for simple differentiation.

Table XXVIII.

This table contains a variety of constant numbers of frequent use in general calculations; it also contains their logarithms to seven places of decimals, and the arithmetical complements of the same. The latter will be found of use in cases where it is required to divide by the numbers in the Table.

Table XXIX.

To reduce the Sun's Declination to any given Meridian, and to any time under that Meridian.

In the "Nautical Almanac" the sun's declination is given for each day at noon at Greenwich; it is, however, necessary for the purposes of navigation to ascertain its declination at any other meridian, either at noon or at any other time of the day. In either of these cases, having obtained the declination from page II. of the month, in the "Nautical Almanac," the correction to be either added or subtracted therefrom, according to the directions given below, may be found in the following manner.

I. *If the sun's declination is required for some other meridian at noon,* reckon the difference of longitude between that meridian and Greenwich, then look for this difference in the first left-hand column of the table, and on the line on which the same is found, and in the vertical column having at its head the nearest number to the declination already taken from the "Nautical Almanac," will be found the correction required. It will be seen in the "Nautical Almanac," whether the sun's declination is increasing or decreasing; when decreasing, add the correction in east longitude, and subtract it in west longitude; but when the declination is increasing, subtract the correction in east longitude, and add it in west longitude.

Example.

What was the sun's declination at noon, on the 13th of November, 1850, in longitude 175° w.?

Here we find, from the "Nautical Almanac," that the sun's declination at noon at Greenwich was 17° 58′ 1″ south, and that it was increasing. We next look in the first column of the table for the given difference of longitude, viz., 175°, but the nearest number that we find is 170°, which is 5° too small, and we must, therefore, add together the corrections found in the proper vertical column on both the lines having 5° and 170° in the first column. Thus, in the present instance, in the column having at its head 18° (the nearest to 17° 58′ 1″,) and on the same line with 5° we find 13″, and on the same line with 170° we find 7′ 22″; these being added together give 7′ 35″ for the required correction, which, as the sun's declination is increasing and the difference of longitude is westerly, has to be *added* to 17° 58′ 1″, making 18° 5′ 36″ for the sun's declination at noon in longitude 175° west.

II. *If the sun's declination is required for Greenwich at any other hour than noon*, reckon the interval between that time and noon; then look for this interval in the last right-hand column of the table, and on the same line in which it is found, and in the vertical column having at its head the nearest number to the sun's declination (from the "Nautical Almanac"), will be found the required correction, which, when the sun's declination is increasing, is to be added, if the time is after noon, and subtracted if before noon; but when the declination is decreasing must be subtracted if the time is after noon, and added if before noon.

Examples.

What was the sun's declination at Greenwich on the 4th of July, 1850, at 7 h. 28 m.?

From the "Nautical Almanac" we find the sun's declination at noon to have been 22° 54′ 58″ north, and to have been decreasing. Then looking in the last column of the table for the nearest number to 7 h. 28 m., we find 7 h. 20 m., and on the same line in the column headed with 23° (the nearest number to 22° 54′ 58″,) we find 1′ 30″, and in the same vertical column on the same line with 8 m. we find 2″, therefore the correction is 1′ 32″, which, as the sun's declination was decreasing, and the time after noon has to be *subtracted* from 22° 54′ 58″, leaving 22° 53′ 26″ north for the sun's declination at the hour required.

What was the sun's declination at Greenwich on the 24th of August, 1850, at 20 h. 12 m.?

In this instance the time given, viz., 20 h. 12 m. on the 24th is equivalent to 3 h. 48 m. before noon on the 25th, for which day the sun's declination is found in the "Nautical Almanac" to have been 10° 48′ 56″ north, and to have been decreasing. Looking then in the column of the table having at its head 11° (the nearest to 10° 48′ 56″,) and on the same line with 3 h. 20 m. we find 2′ 56″, and on the same line with 28 m. we find 25″; adding these two together, we obtain 3′ 21″ for the correction, which, as the sun's declination is decreasing, and the time before noon,

must be *added* to 10° 48′ 56″, making 10° 52′ 17″ north for the sun's declination at the time required.

III. *If the sun's declination is required for some other meridian than Greenwich, at any other hour than noon,* we must first make the necessary correction for the difference of longitude in the manner already explained, and then the correction for time according to rule II.

Examples.

What was the sun's declination on the 17th of May, 1850, at 5 h. 40 m., in longitude 128° E.?

Sun's declination (increasing) at Greenwich, at noon		19°	18′ 38″ N.
Subtract correction for 120°	4′ 46″	0	5 5
Subtract correction for 8°	0 19		
		19	13 33
Add correction for 5 h. 20 m.	3′ 11″	0	3 23
Add correction for 0 h. 20 m.	0 12		
Sun's declination at the time and place required .		19	16 56 N.

What was the sun's declination on the 3rd of June, 1850, at 17 h. 20 m., in longitude 79° W.?

17 h. 20 m. on the 3rd, is equivalent to 6 h. 40 m. on the 4th.

Sun's declination (increasing) at Greenwich, at noon		22°	25′ 47″ N.
Add correction for 70°	1′ 41″	0	1 53
Add correction for 9°	0 12		
		22	27 40
Subtract correction for 6 h. 40 m.		0	2 24
Sun's declination at the time and place required . .		22	25 16 N.

When the sun is near either of the equinoxes its declination may be less than the correction, in which case, when the correction is subtractive, the declination must be subtracted from it, and the remainder will be the sun's declination of a *contrary name* to that which it was before.

Example.

What was the sun's declination at noon on the 23rd of September, 1850, in longitude 164° E?

The sun's declination (increasing) at noon, at Greenwich		0°	1′ 57″ S.
Subtract correction for 160° at noon . .	10′ 25″	0	10 41
Subtract correction for 4°	0 16		
Sun's declination at the place required		0	8 44 N.

No. 100 L. 000.]				LOGARITHMS OF NUMBERS.						[No. 109 L. 040.	
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1	4321	4751	5181	5609	6038	6466	6894	7321	7748	8174	1
2	8600	9026	9451	9876	0300	0724	1147	1570	1993	2415	2
3	012837	3259	3680	4100	4521	4940	5360	5779	6197	6616	3
4	7033	7451	7868	8284	8700	9116	9532	9947	0361	0775	4
5	021189	1603	2016	2428	2841	3252	3664	4075	4486	4896	5
6	5306	5715	6125	6533	6942	7350	7757	8164	8571	8978	6
7	9384	9789	0195	0600	1004	1408	1812	2216	2619	3021	7
8	033424	3826	4227	4628	5029	5430	5830	6230	6629	7028	8
9	7426	7825	8223	8620	9017	9414	9811	0207	0602	0998	9

PROPORTIONAL PARTS.

N.	1	2	3	4	5	6	7	8	9
1000	43·4	86·8	130·2	173·6	217·0	260·4	303·8	347·2	390·6
1002	43·3	86·6	129·9	173·2	216·5	259·8	303·1	346·4	389·7
1004	43·2	86·4	129·6	172·8	216·0	259·2	302·4	345·6	388·8
1006	43·1	86·2	129·3	172·4	215·5	258·6	301·7	344·8	387·9
1009	43·0	86·0	129·0	172·0	215·0	258·0	301·0	344·0	387·0
1011	42·9	85·8	128·7	171·6	214·5	257·4	300·3	343·2	386·1
1014	42·8	85·6	128·4	171·2	214·0	256·8	299·6	342·4	385·2
1016	42·7	85·4	128·1	170·8	213·5	256·2	298·9	341·6	384·3
1018	42·6	85·2	127·8	170·4	213·0	255·6	298·2	340·8	383·4
1020	42·5	85·0	127·5	170·0	212·5	255·0	297·5	340·0	382·5
1023	42·4	84·8	127·2	169·6	212·0	254·4	296·8	339·2	381·6
1026	42·3	84·6	126·9	169·2	211·5	253·8	296·1	338·4	380·7
1028	42·2	84·4	126·6	168·8	211·0	253·2	295·4	337·6	379·8
1030	42·1	84·2	126·3	168·4	210·5	252·6	294·7	336·8	378·9
1033	42·0	84·0	126·0	168·0	210·0	252·0	294·0	336·0	378·0
1035	41·9	83·8	125·7	167·6	209·5	251·4	293·3	335·2	377·1
1038	41·8	83·6	125·4	167·2	209·0	250·8	292·6	334·4	376·2
1040	41·7	83·4	125·1	166·8	208·5	250·2	291·9	333·6	375·3
1043	41·6	83·2	124·8	166·4	208·0	249·6	291·2	332·8	374·4
1045	41·5	83·0	124·5	166·0	207·5	249·0	290·5	332·0	373·5
1048	41·4	82·8	124·2	165·6	207·0	248·4	289·8	331·2	372·6
1050	41·3	82·6	123·9	165·2	206·5	247·8	289·1	330·4	371·7
1053	41·2	82·4	123·6	164·8	206·0	247·2	288·4	329·6	370·8
1055	41·1	82·2	123·3	164·4	205·5	246·6	287·7	328·8	369·9
1058	41·0	82·0	123·0	164·0	205·0	246·0	287·0	328·0	369·0
1060	40·9	81·8	122·7	163·6	204·5	245·4	286·3	327·2	368·1
1063	40·8	81·6	122·4	163·2	204·0	244·8	285·6	326·4	367·2
1066	40·7	81·4	122·1	162·8	203·5	244·2	284·9	325·6	366·3
1068	40·6	81·2	121·8	162·4	203·0	243·6	284·2	324·8	365·4
1071	40·5	81·0	121·5	162·0	202·5	243·0	283·5	324·0	364·5
1074	40·4	80·8	121·2	161·6	202·0	242·4	282·8	323·2	363·6
1076	40·3	80·6	120·9	161·2	201·5	241·8	282·1	322·4	362·7
1079	40·2	80·4	120·6	160·8	201·0	241·2	281·4	321·6	361·8
1082	40·1	80·2	120·3	160·4	200·5	240·6	280·7	320·8	360·9
1084	40·0	80·0	120·0	160·0	200·0	240·0	280·0	320·0	360·0
1087	39·9	79·8	119·7	159·6	199·5	239·4	279·3	319·2	359·1
1090	39·8	79·6	119·4	159·2	199·0	238·8	278·6	318·4	358·2
1093	39·7	79·4	119·1	158·8	198·5	238·2	277·9	317·6	357·3
1095	39·6	79·2	118·8	158·4	198·0	237·6	277·2	316·8	356·4
1098	39·5	79·0	118·5	158·0	197·5	237·0	276·5	316·0	355·5

No. 110 L 041.] LOGARITHMS OF NUMBERS. [No. 119 L. 078.

N.	0	1	2	3	4	5	6	7	8	9	N.
110	041393	1787	2182	2576	2969	3362	3755	4148	4540	4932	110
1	5323	5714	6105	6495	6885	7275	7664	8053	8442	8830	1
2	9218	9606	9993	0380	0766	1153	1538	1924	2309	2694	2
3	053078	3463	3846	4230	4613	4996	5378	5760	6142	6524	3
4	6905	7286	7666	8046	8426	8805	9185	9563	9942	0320	4
5	060698	1075	1452	1829	2206	2582	2958	3333	3709	4083	5
6	4458	4832	5206	5580	5953	6326	6699	7071	7443	7815	6
7	8186	8557	8928	9298	9668	0038	0407	0776	1145	1514	7
8	071882	2250	2617	2985	3352	3718	4085	4451	4816	5182	8
9	5547	5912	6276	6640	7004	7368	7731	8094	8457	8819	9

PROPORTIONAL PARTS.

N.	1	2	3	4	5	6	7	8	9
1101	39·4	78·8	118·2	157·6	197·0	236·4	275·8	315·2	354·6
1104	39·3	78·6	117·9	157·2	196·5	235·8	275·1	314·4	353·7
1106	39·2	78·4	117·6	156·8	196·0	235·2	274·4	313·6	352·8
1109	39·1	78·2	117·3	156·4	195·5	234·6	273·7	312·8	351·9
1112	39·0	78·0	117·0	156·0	195·0	234·0	273·0	312·0	351·0
1115	38·9	77·8	116·7	155·6	194·5	233·4	272·3	311·2	350·1
1118	38·8	77·6	116·4	155·2	194·0	232·8	271·6	310·4	349·2
1121	38·7	77·4	116·1	154·8	193·5	232·2	270·9	309·6	348·3
1124	38·6	77·2	115·8	154·4	193·0	231·6	270·2	308·8	347·4
1127	38·5	77·0	115·5	154·0	192·5	231·0	269·5	308·0	346·5
1129	38·4	76·8	115·2	153·6	192·0	230·4	268·8	307·2	345·6
1132	38·3	76·6	114·9	153·2	191·5	229·8	268·1	306·4	344·7
1135	38·2	76·4	114·6	152·8	191·0	229·2	267·4	305·6	343·8
1138	38·1	76·2	114·3	152·4	190·5	228·6	266·7	304·8	342·9
1141	38·0	76·0	114·0	152·0	190·0	228·0	266·0	304·0	342·0
1144	37·9	75·8	113·7	151·6	189·5	227·4	265·3	303·2	341·1
1148	37·8	75·6	113·4	151·2	189·0	226·8	264·6	302·4	340·2
1151	37·7	75·4	113·1	150·8	188·5	226·2	263·9	301·6	339·3
1154	37·6	75·2	112·8	150·4	188·0	225·6	263·2	300·8	338·4
1157	37·5	75·0	112·5	150·0	187·5	225·0	262·5	300·0	337·5
1160	37·4	74·8	112·2	149·6	187·0	224·4	261·8	299·2	336·6
1163	37·3	74·6	111·9	149·2	186·5	223·8	261·1	298·4	335·7
1166	37·2	74·4	111·6	148·8	186·0	223·2	260·4	297·6	334·8
1169	37·1	74·2	111·3	148·4	185·5	222·6	259·7	296·8	333·9
1172	37·0	74·0	111·0	148·0	185·0	222·0	259·0	296·0	333·0
1175	36·9	73·8	110·7	147·6	184·5	221·4	258·3	295·2	332·1
1178	36·8	73·6	110·4	147·2	184·0	220·8	257·6	294·4	331·2
1182	36·7	73·4	110·1	146·8	183·5	220·2	256·9	293·6	330·3
1185	36·6	73·2	109·8	146·4	183·0	219·6	256·2	292·8	329·4
1188	36·5	73·0	109·5	146·0	182·5	219·0	255·7	292·0	328·5
1192	36·4	72·8	109·2	145·6	182·0	218·4	254·8	291·2	327·6
1195	36·3	72·6	108·9	145·2	181·5	217·8	254·1	290·4	326·7
1198	36·2	72·4	108·6	144·8	181·0	217·2	253·4	289·6	325·8
1202	36·1	72·2	108·3	144·4	180·5	216·6	252·7	288·8	324·9
1205	36·0	72·0	108·0	144·0	180·0	216·0	252·0	288·0	324·0
1208	35·9	71·8	107·7	143·6	179·5	215·4	251·3	287·2	323·1
1212	35·8	71·6	107·4	143·2	179·0	214·8	250·6	286·4	322·2
1215	35·7	71·4	107·1	142·8	178·5	214·2	249·9	285·6	321·3
1218	35·6	71·2	106·8	142·4	178·0	213·6	249·2	284·8	320·4

No. 120 L. 079.]				LOGARITHMS OF NUMBERS.						[No. 134 L. 130.	
N.	0	1	2	3	4	5	6	7	8	9	N.
120	079181	9543	9904	0266	0626	0987	1347	1707	2067	2426	120
1	082785	3144	3503	3861	4219	4576	4934	5291	5647	6004	1
2	6360	6716	7071	7426	7781	8136	8490	8845	9198	9552	2
3	9905	0258	0611	0963	1315	1667	2018	2370	2721	3071	3
4	093422	3772	4122	4471	4820	5169	5518	5866	6215	6562	4
5	6910	7257	7604	7951	8298	8644	8990	9335	9681	0026	5
6	100371	0715	1059	1403	1747	2091	2434	2777	3119	3462	6
7	3804	4146	4487	4828	5169	5510	5851	6191	6531	6871	7
8	7210	7549	7888	8227	8565	8903	9241	9579	9916	0253	8
9	110590	0926	1263	1599	1934	2270	2605	2940	3275	3609	9
130	3943	4277	4611	4644	5278	5611	5943	6276	6608	6940	130
1	7271	7603	7934	8265	8595	8926	9256	9586	9915	0245	1
2	120574	0903	1231	1560	1888	2216	2544	2871	3198	3525	2
3	3852	4178	4504	4830	5156	5481	5806	6131	6456	6781	3
4	7105	7429	7753	8076	8399	8722	9045	9368	9690	0012	4

PROPORTIONAL PARTS.										
N.	1	2	3	4	5	6	7	8	9	
1222	35·5	71·0	106·5	142·0	177·5	213·0	248·5	284·0	319·5	
1225	35·4	70·8	106·2	141·6	177·0	212·4	247·8	283·2	318·6	
1228	35·3	70·6	105·9	141·2	176·5	211·8	247·1	282·4	317·7	
1231	35·2	70·4	105·6	140·8	176·0	211·2	246·4	281·6	316·8	
1235	35·1	70·2	105·3	140·4	175·5	210·6	245·7	280·8	315·9	
1239	35·0	70·0	105·0	140·0	175·0	210·0	245·0	280·0	315·0	
1243	34·9	69·8	104·7	139·6	174·5	209·4	244·3	279·2	314·1	
1247	34·8	69·6	104·4	139·2	174·0	208·8	243·6	278·4	313·2	
1250	34·7	69·4	104·1	138·8	173·5	208·2	242·9	277·6	312·3	
1253	34·6	69·2	103·8	138·4	173·0	207·6	242·2	276·8	311·4	
1257	34·5	69·0	103·5	138·0	172·5	207·0	241·5	276·0	310·5	
1261	34·4	68·8	103·2	137·6	172·0	206·4	240·8	275·2	309·6	
1264	34·3	68·6	102·9	137·2	171·5	205·8	240·1	274·4	308·7	
1268	34·2	68·4	102·6	136·8	171·0	205·2	239·4	273·6	307·8	
1272	34·1	68·2	102·3	136·4	170·5	204·6	238·7	272·8	306·9	
1276	34·0	68·0	102·0	136·0	170·0	204·0	238·0	272·0	306·0	
1279	33·9	67·8	101·7	135·6	169·5	203·4	237·3	271·2	305·1	
1283	33·8	67·6	101·4	135·2	169·0	202·8	236·6	270·4	304·2	
1287	33·7	67·4	101·1	134·8	168·5	202·2	235·9	269·6	303·3	
1291	33·6	67·2	100·8	134·4	168·0	201·6	235·2	268·8	302·4	
1295	33·5	67·0	100·5	134·0	167·5	201·0	234·5	268·0	301·5	
1298	33·4	66·8	100·2	133·6	167·0	200·4	233·8	267·2	300·6	
1302	33·3	66·6	99·9	133·2	166·5	199·8	233·1	266·4	299·7	
1306	33·2	66·4	99·6	132·8	166·0	199·2	232·4	265·6	298·8	
1310	33·1	66·2	99·3	132·4	165·5	198·6	231·7	264·8	297·9	
1314	33·0	66·0	99·0	132·0	165·0	198·0	231·0	264·0	297·0	
1318	32·9	65·8	98·7	131·6	164·5	197·4	230·3	263·2	296·1	
1322	32·8	65·6	98·4	131·2	164·0	196·8	229·6	262·4	295·2	
1326	32·7	65·4	98·1	130·8	163·5	196·2	228·9	261·6	294·3	
1330	32·6	65·2	97·8	130·4	163·0	195·6	228·2	260·8	293·4	
1334	32·5	65·0	97·5	130·0	162·5	195·0	227·5	260·0	292·5	
1338	32·4	64·8	97·2	129·6	162·0	194·4	226·8	259·2	291·6	
1343	32·3	64·6	96·9	129·2	161·5	193·8	226·1	258·4	290·7	
1347	32·2	64·4	96·6	128·8	161·0	193·2	225·4	257·6	289·8	

No. 135 L. 130.]	LOGARITHMS OF NUMBERS.									[No. 149 L. 175.	
N.	0	1	2	3	4	5	6	7	8	9	N.
135	130334	0655	0977	1298	1619	1939	2260	2580	2900	3219	135
6	3539	3858	4177	4496	4814	5133	5451	5769	6086	6403	6
7	6721	7037	7354	7671	7987	8303	8618	8934	9249	9564	7
8	9879	0194	0508	0822	1136	1450	1763	2076	2389	2702	8
9	143015	3327	3639	3951	4263	4574	4885	5196	5507	5818	9
140	6128	6438	6748	7058	7367	7676	7985	8294	8603	8911	140
1	9219	9527	9835	0142	0449	0756	1063	1370	1676	1982	1
2	152288	2594	2900	3205	3510	3815	4120	4424	4728	5032	2
3	5336	5640	5943	6246	6549	6852	7154	7457	7759	8061	3
4	8362	8664	8965	9266	9567	9868	0168	0469	0769	1068	4
5	161368	1667	1967	2266	2564	2863	3161	3460	3758	4055	5
6	4353	4650	4947	5244	5541	5838	6134	6430	6726	7022	6
7	7317	7613	7908	8203	8497	8792	9086	9380	9674	9968	7
8	170262	0555	0848	1141	1434	1726	2019	2311	2603	2895	8
9	3186	3478	3769	4060	4351	4641	4932	5222	5512	5802	9

PROPORTIONAL PARTS.

N.	1	2	3	4	5	6	7	8	9
1351	32·1	64·2	96·3	128·4	160·5	192·6	224·7	256·8	288·9
1355	32·0	64·0	96·0	128·0	160·0	192·0	224·0	256·0	288·0
1359	31·9	63·8	95·7	127·6	159·5	191·4	223·3	255·2	287·1
1364	31·8	63·6	95·4	127·2	159·0	190·8	222·6	254·4	286·2
1368	31·7	63·4	95·1	126·8	158·5	190·2	221·9	253·6	285·3
1372	31·6	63·2	94·8	126·4	158·0	189·6	221·2	252·8	284·4
1376	31·5	63·0	94·5	126·0	157·5	189·0	220·5	252·0	283·5
1381	31·4	62·8	94·2	125·6	157·0	188·4	219·8	251·2	282·6
1385	31·3	62·6	93·9	125·2	156·5	187·8	219·1	250·4	281·7
1390	31·2	62·4	93·6	124·8	156·0	187·2	218·4	249·6	280·8
1394	31·1	62·2	93·3	124·4	155·5	186·6	217·7	248·8	279·9
1398	31·0	62·0	93·0	124·0	155·0	186·0	217·0	248·0	279·0
1403	30·9	61·8	92·7	123·6	154·5	185·4	216·3	247·2	278·1
1408	30·8	61·6	92·4	123·2	154·0	184·8	215·6	246·4	277·2
1412	30·7	61·4	92·1	122·8	153·5	184·2	214·9	245·6	276·3
1417	30·6	61·2	91·8	122·4	153·0	183·6	214·2	244·8	275·4
1422	30·5	61·0	91·5	122·0	152·5	183·0	213·5	244·0	274·5
1426	30·4	60·8	91·2	121·6	152·0	182·4	212·8	243·2	273·6
1431	30·3	60·6	90·9	121·2	151·5	181·8	212·1	242·4	272·7
1436	30·2	60·4	90·6	120·8	151·0	181·2	211·4	241·6	271·8
1441	30·1	60·2	90·3	120·4	150·5	180·6	210·7	240·8	270·9
1446	30·0	60·0	90·0	120·0	150·0	180·0	210·0	240·0	270·0
1450	29·9	59·8	89·7	119·6	149·5	179·4	209·3	239·2	269·1
1455	29·8	59·6	89·4	119·2	149·0	178·8	208·6	238·4	268·2
1460	29·7	59·4	89·1	118·8	148·5	178·2	207·9	237·6	267·3
1465	29·6	59·2	88·8	118·4	148·0	177·6	207·2	236·8	266·4
1470	29·5	59·0	88·5	118·0	147·5	177·0	206·5	236·0	265·5
1475	29·4	58·8	88·2	117·6	147·0	176·4	205·8	235·2	264·6
1480	29·3	58·6	87·9	117·2	146·5	175·8	205·1	234·4	263·7
1485	29·2	58·4	87·6	116·8	146·0	175·2	204·4	233·6	262·8
1490	29·1	58·2	87·3	116·4	145·5	174·6	203·7	232·8	261·9
1495	29·0	58·0	87·0	116·0	145·0	174·0	203·0	232·0	261·0
1500	28·9	57·8	86·7	115·6	144·5	173·4	202·3	231·2	260·1
1505	28·8	57·6	86·4	115·2	144·0	172·8	201·6	230·4	259·2
1511	28·7	57·4	86·1	114·8	143·5	172·2	200·9	229·6	258·3
1516	28·6	57·2	85·8	114·4	143·0	171·6	200·2	228·8	257·4

No. 150 L. 176.]	LOGARITHMS OF NUMBERS.									[No. 169 L. 230.	
N.	0	1	2	3	4	5	6	7	8	9	N.
150	176091	6381	6670	6959	7248	7536	7825	8113	8401	8689	150
1	8977	9264	9552	9839	0126	0413	0699	0986	1272	1558	1
2	181844	2129	2415	2700	2985	3270	3555	3839	4123	4407	2
3	4691	4975	5259	5542	5825	6108	6391	6674	6956	7239	3
4	7521	7803	8084	8366	8647	8928	9209	9490	9771	0051	4
5	190332	0612	0892	1171	1451	1730	2010	2289	2567	2846	5
6	3125	3403	3681	3959	4237	4514	4792	5069	5346	5623	6
7	5900	6176	6453	6729	7005	7281	7556	7832	8107	8382	7
8	8657	8932	9206	9481	9755	0029	0303	0577	0850	1124	8
9	201397	1670	1943	2216	2488	2761	3033	3305	3577	3848	9
160	4120	4391	4663	4934	5204	5475	5746	6016	6286	6556	160
1	6826	7096	7365	7634	7904	8173	8441	8710	8979	9247	1
2	9515	9783	0051	0319	0586	0853	1121	1388	1654	1921	2
3	212188	2454	2720	2986	3252	3518	3783	4049	4314	4579	3
4	4844	5109	5373	5638	5902	6166	6430	6694	6957	7221	4
5	7484	7747	8010	8273	8536	8798	9060	9323	9585	9846	5
6	220108	0370	0631	0892	1153	1414	1675	1936	2196	2456	6
7	2716	2976	3236	3496	3755	4015	4274	4533	4792	5051	7
8	5309	5568	5826	6084	6342	6600	6858	7115	7372	7630	8
9	7887	8144	8400	8657	8913	9170	9426	9682	9938	0193	9

PROPORTIONAL PARTS.

N.	1	2	3	4	5	6	7	8	9
1521	28·5	57·0	85·5	114·0	142·5	171·0	199·5	228·0	256·5
1527	28·4	56·8	85·2	113·6	142·0	170·4	198·8	227·2	255·6
1532	28·3	56·6	84·9	113·2	141·5	169·8	198·1	226·4	254·7
1537	28·2	56·4	84·6	112·8	141·0	169·2	197·4	225·6	253·8
1543	28·1	56·2	84·3	112·4	140·5	168·6	196·7	224·8	252·9
1548	28·0	56·0	84·0	112·0	140·0	168·0	196·0	224·0	252·0
1554	27·9	55·8	83·7	111·6	139·5	167·4	195·3	223·2	251·1
1559	27·8	55·6	83·4	111·2	139·0	166·8	194·6	222·4	250·2
1565	27·7	55·4	83·1	110·8	138·5	166·2	193·9	221·6	249·3
1570	27·6	55·2	82·8	110·4	138·0	165·6	193·2	220·8	248·4
1576	27·5	55·0	82·5	110·0	137·5	165·0	192·5	220·0	247·5
1582	27·4	54·8	82·2	109·6	137·0	164·4	191·8	219·2	246·6
1587	27·3	54·6	81·9	109·2	136·5	163·8	191·1	218·4	245·7
1593	27·2	54·4	81·6	108·8	136·0	163·2	190·4	217·6	244·8
1599	27·1	54·2	81·3	108·4	135·5	162·6	189·7	216·8	243·9
1605	27·0	54·0	81·0	108·0	135·0	162·0	189·0	216·0	243·0
1611	26·9	53·8	80·7	107·6	134·5	161·4	188·3	215·2	242·1
1617	26·8	53·6	80·4	107·2	134·0	160·8	187·6	214·4	241·2
1623	26·7	53·4	80·1	106·8	133·5	160·2	186·9	213·6	240·3
1629	26·6	53·2	79·8	106·4	133·0	159·6	186·2	212·8	239·4
1635	26·5	53·0	79·5	106·0	132·5	159·0	185·5	212·0	238·5
1641	26·4	52·8	79·2	105·6	132·0	158·4	184·8	211·2	237·6
1648	26·3	52·6	78·9	105·2	131·5	157·8	184·1	210·4	236·7
1654	26·2	52·4	78·6	104·8	131·0	157·2	183·4	209·6	235·8
1660	26·1	52·2	78·3	104·4	130·5	156·6	182·7	208·8	234·9
1667	26·0	52·0	78·0	104·0	130·0	156·0	182·0	208·0	234·0
1673	25·9	51·8	77·7	103·6	129·5	155·4	181·3	207·2	233·1
1680	25·8	51·6	77·4	103·2	129·0	154·8	180·6	206·4	232·2
1686	25·7	51·4	77·1	102·8	128·5	154·2	179·9	205·6	231·3
1693	25·6	51·2	76·8	102·4	128·0	153·6	179·2	204·8	230·4
1699	25·5	51·0	76·5	102·0	127·5	153·0	178·5	204·0	229·5

No. 170 L. 230.] LOGARITHMS OF NUMBERS. [No. 189 L. 278.

N.	0	1	2	3	4	5	6	7	8	9	N.
170	230449	0704	0960	1215	1470	1724	1979	2234	2488	2742	170
1	2996	3250	3504	3757	4011	4264	4517	4770	5023	5276	1
2	5528	5781	6033	6285	6537	6789	7041	7292	7544	7795	2
3	8046	8297	8548	8799	9049	9299	9550	9800	0050	0300	3
4	240549	0799	1048	1297	1546	1795	2044	2293	2541	2790	4
5	3038	3286	3534	3782	4030	4277	4525	4772	5019	5266	5
6	5513	5759	6006	6252	6499	6745	6991	7237	7482	7728	6
7	7973	8219	8464	8709	8954	9198	9443	9687	9932	0176	7
8	250420	0664	0908	1151	1395	1638	1881	2125	2368	2610	8
9	2853	3096	3338	3580	3822	4064	4306	4548	4790	5031	9
180	5273	5514	5755	5996	6237	6477	6718	6958	7198	7439	180
1	7679	7918	8158	8398	8637	8877	9116	9355	9594	9833	1
2	260071	0310	0548	0787	1025	1263	1501	1739	1976	2214	2
3	2451	2688	2925	3162	3399	3636	3873	4109	4346	4582	3
4	4818	5054	5290	5525	5761	5996	6232	6467	6702	6937	4
5	7172	7406	7641	7875	8110	8344	8578	8812	9046	9279	5
6	9513	9746	9980	0213	0446	0679	0912	1144	1377	1609	6
7	271842	2074	2306	2538	2770	3001	3233	3464	3696	3927	7
8	4158	4389	4620	4850	5081	5311	5542	5772	6002	6232	8
9	6462	6692	6921	7151	7380	7609	7838	8067	8296	8525	9

PROPORTIONAL PARTS.

N.	1	2	3	4	5	6	7	8	9
1706	25·4	50·8	76·2	101·6	127·0	152·4	177·8	203·2	228·6
1713	25·3	50·6	75·9	101·2	126·5	151·8	177·1	202·4	227·7
1719	25·2	50·4	75·6	100·8	126·0	151·2	176·4	201·6	226·8
1726	25·1	50·2	75·3	100·4	125·5	150·6	175·7	200·8	225·9
1733	25·0	50·0	75·0	100·0	125·0	150·0	175·0	200·0	225·0
1740	24·9	49·8	74·7	99·6	124·5	149·4	174·3	199·2	224·1
1747	24·8	49·6	74·4	99·2	124·0	148·8	173·6	198·4	223·2
1754	24·7	49·4	74·1	98·8	123·5	148·2	172·9	197·6	222·3
1761	24·6	49·2	73·8	98·4	123·0	147·6	172·2	196·8	221·4
1769	24·5	49·0	73·5	98·0	122·5	147·0	171·5	196·0	220·5
1776	24·4	48·8	73·2	97·6	122·0	146·4	170·8	195·2	219·6
1783	24·3	48·6	72·9	97·2	121·5	145·8	170·1	194·4	218·7
1790	24·2	48·4	72·6	96·8	121·0	145·2	169·4	193·6	217·8
1798	24·1	48·2	72·3	96·4	120·5	144·6	168·7	192·8	216·9
1805	24·0	48·0	72·0	96·0	120·0	144·0	168·0	192·0	216·0
1813	23·9	47·8	71·7	95·6	119·5	143·4	167·3	191·2	215·1
1820	23·8	47·6	71·4	95·2	119·0	142·8	166·6	190·4	214·2
1828	23·7	47·4	71·1	94·8	118·5	142·2	165·9	189·6	213·3
1836	23·6	47·2	70·8	94·4	118·0	141·6	165·2	188·8	212·4
1844	23·5	47·0	70·5	94·0	117·5	141·0	164·5	188·0	211·5
1852	23·4	46·8	70·2	93·6	117·0	140·4	163·8	187·2	210·6
1859	23·3	46·6	69·9	93·2	116·5	139·8	163·1	186·4	209·7
1867	23·2	46·4	69·6	92·8	116·0	139·2	162·4	185·6	208·8
1876	23·1	46·2	69·3	92·4	115·5	138·6	161·7	184·8	207·9
1884	23·0	46·0	69·0	92·0	115·0	138·0	161·0	184·0	207·0
1892	22·9	45·8	68·7	91·6	114·5	137·4	160·3	183·2	206·1
1900	22·8	45·6	68·4	91·2	114·0	136·8	159·6	182·4	205·2
1908	22·7	45·4	68·1	90·8	113·5	136·2	158·9	181·6	204·3
1917	22·6	45·2	67·8	90·4	113·0	135·6	158·2	180·8	203·4

No. 190 L. 278.] LOGARITHMS OF NUMBERS. [No. 214 L. 332.

N.	0	1	2	3	4	5	6	7	8	9	N.
190	278754	8982	9211	9439	9667	9895	0123	0351	0578	0806	190
1	281033	1261	1488	1715	1942	2169	2396	2622	2849	3075	1
2	3301	3527	3753	3979	4205	4431	4656	4882	5107	5332	2
3	5557	5782	6007	6232	6456	6681	6905	7130	7354	7578	3
4	7802	8026	8249	8473	8696	8920	9143	9366	9589	9812	4
5	290035	0257	0480	0702	0925	1147	1369	1591	1813	2034	5
6	2256	2478	2699	2920	3141	3363	3584	3804	4025	4246	6
7	4466	4687	4907	5127	5347	5567	5787	6007	6226	6446	7
8	6665	6884	7104	7323	7542	7761	7979	8198	8416	8635	8
9	8853	9071	9289	9507	9725	9943	0161	0378	0595	0813	9
200	301030	1247	1464	1681	1898	2114	2331	2547	2764	2980	200
1	3196	3412	3628	3844	4059	4275	4491	4706	4921	5136	1
2	5351	5566	5781	5996	6211	6425	6639	6854	7068	7282	2
3	7496	7710	7924	8137	8351	8564	8778	8991	9204	9417	3
4	9630	9843	0056	0268	0481	0693	0906	1118	1330	1542	4
5	311754	1966	2177	2389	2600	2812	3023	3234	3445	3656	5
6	3867	4078	4289	4499	4710	4920	5130	5340	5551	5760	6
7	5970	6180	6390	6599	6809	7018	7227	7436	7646	7854	7
8	8063	8272	8481	8689	8898	9106	9314	9522	9730	9938	8
9	320146	0354	0562	0769	0977	1184	1391	1598	1805	2012	9
210	2219	2426	2633	2839	3046	3252	3458	3665	3871	4077	210
1	4282	4488	4694	4899	5105	5310	5516	5721	5926	6131	1
2	6336	6541	6745	6950	7155	7359	7563	7767	7972	8176	2
3	8380	8583	8787	8991	9194	9398	9601	9805	0008	0211	3
4	330414	0617	0819	1022	1225	1427	1630	1832	2034	2236	4

PROPORTIONAL PARTS.

N.	1	2	3	4	5	6	7	8	9
1925	22·5	45·0	67·5	90·0	112·5	135·0	157·5	180·0	202·5
1934	22·4	44·8	67·2	89·6	112·0	134·4	156·8	179·2	201·6
1943	22·3	44·6	66·9	89·2	111·5	133·8	156·1	178·4	200·7
1952	22·2	44·4	66·6	88·8	111·0	133·2	155·4	177·6	199·8
1961	22·1	44·2	66·3	88·4	110·5	132·6	154·7	176·8	198·9
1969	22·0	44·0	66·0	88·0	110·0	132·0	154·0	176·0	198·0
1978	21·9	43·8	65·7	87·6	109·5	131·4	153·3	175·2	197·1
1987	21·8	43·6	65·4	87·2	109·0	130·8	152·6	174·4	196·2
1996	21·7	43·4	65·1	86·8	108·5	130·2	151·9	173·6	195·3
2005	21·6	43·2	64·8	86·4	108·0	129·6	151·2	172·8	194·4
2015	21·5	43·0	64·5	86·0	107·5	129·0	150·5	172·0	193·5
2024	21·4	42·8	64·2	85·6	107·0	128·4	149·8	171·2	192·6
2034	21·3	42·6	63·9	85·2	106·5	127·8	149·1	170·4	191·7
2043	21·2	42·4	63·6	84·8	106·0	127·2	148·4	169·6	190·8
2053	21·1	42·2	63·3	84·4	105·5	126·6	147·7	168·8	189·9
2063	21·0	42·0	63·0	84·0	105·0	126·0	147·0	168·0	189·0
2073	20·9	41·8	62·7	83·6	104·5	125·4	146·3	167·2	188·1
2082	20·8	41·6	62·4	83·2	104·0	124·8	145·6	166·4	187·2
2092	20·7	41·4	62·1	82·8	103·5	124·2	144·9	165·6	186·3
2103	20·6	41·2	61·8	82·4	103·0	123·6	144·2	164·8	185·4
2113	20·5	40·0	61·5	82·0	102·5	123·0	143·5	164·0	184·5
2123	20·4	40·8	61·2	81·6	102·0	122·4	142·8	163·2	183·6
2134	20·3	40·6	60·9	81·2	101·5	121·8	142·1	162·4	182·7
2144	20·2	40·4	60·6	80·8	101·0	121·2	141·4	161·6	181·8

No. 215 L. 332.]	LOGARITHMS OF NUMBERS.									[No. 239 L. 380.	
N.	0	1	2	3	4	5	6	7	8	9	N.
215	332438	2640	2842	3044	3246	3447	3649	3850	4051	4253	215
6	4454	4655	4856	5057	5257	5458	5658	5859	6059	6260	6
7	6460	6660	6860	7060	7260	7459	7659	7858	8058	8257	7
8	8456	8656	8855	9054	9253	9451	9650	9849	0047	0246	8
9	340444	0642	0841	1039	1237	1435	1632	1830	2028	2225	9
220	2423	2620	2817	3014	3212	3409	3606	3802	3999	4196	220
1	4392	4589	4785	4981	5178	5374	557c	5766	5962	6157	1
2	6353	6549	6744	6939	7135	7330	7525	7720	7915	8110	2
3	8305	8500	8694	8889	9083	9278	9472	9666	9860	0054	3
4	350248	0442	0636	0829	1023	1216	1410	1603	1796	1989	4
5	2183	2375	2568	2761	2954	3147	3339	3532	3724	3916	5
6	4108	4301	4493	4685	4876	5068	5260	5452	5643	5834	6
7	6026	6217	6408	6599	6790	6981	7172	7363	7554	7744	7
8	7935	8125	8316	8506	8696	8886	9076	9266	9456	9646	8
9	9835	0025	0215	0404	0593	0783	0972	1161	1350	1539	9
230	361728	1917	2105	2294	2482	2671	2859	3048	3236	3424	230
1	3612	3800	3988	4176	4363	4551	4739	4926	5113	5301	1
2	5488	5675	5862	6049	6236	6423	6610	6796	6983	7169	2
3	7356	7542	7729	7915	8101	8287	8473	8659	8845	9030	3
4	9216	9401	9587	9772	9958	0143	0328	0513	0698	0883	4
5	371068	1253	1437	1622	1806	1991	2175	2360	2544	2728	5
6	2912	3096	3280	3464	3647	3831	4015	4198	4382	4565	6
7	4748	4932	5115	5298	5481	5664	5846	6029	6212	6394	7
8	6577	6759	6942	7124	7306	7488	7670	7852	8034	8216	8
9	8398	8580	8761	8943	9124	9306	9487	9668	9849	0030	9

PROPORTIONAL PARTS.

N.	1	2	3	4	5	6	7	8	9
2155	20·1	40·2	60·3	80·4	100·5	120·6	140·7	160·8	180·9
2166	20·0	40·0	60·0	80·0	100·0	120·0	140·0	160·0	180·0
2176	19·9	39·8	59·7	79·6	99·5	119·4	139·3	159·2	179·1
2187	19·8	39·6	59·4	79·2	99·0	118·8	138·6	158·4	178·2
2198	19·7	39·4	59·1	78·8	98·5	118·2	137·9	157·6	177·3
2210	19·6	39·2	58·8	78·4	98·0	117·6	137·2	156·8	176·4
2221	19·5	39·0	58·5	78·0	97·5	117·0	136·5	156·0	175·5
2232	19·4	38·8	58·2	77·6	97·0	116·4	135·8	155·2	174·6
2244	19·3	38·6	57·9	77·2	96·5	115·8	135·1	154·4	173·7
2256	19·2	38·4	57·6	76·8	96·0	115·2	134·4	153·6	172·8
2267	19·1	38·2	57·3	76·4	95·5	114·6	133·7	152·8	171·9
2279	19·0	38·0	57·0	76·0	95·0	114·0	133·0	152·0	171·0
2291	18·9	37·8	56·7	75·6	94·5	113·4	132·3	151·2	170·1
2303	18·8	37·6	56·4	75·2	94·0	112·8	131·6	150·4	169·2
2316	18·7	37·4	56·1	74·8	93·5	112·2	130·9	149·6	168·3
2328	18·6	37·2	55·8	74·4	93·0	111·6	130·2	148·8	167·4
2341	18·5	37·0	55·5	74·0	92·5	111·0	129·5	148·0	166·5
2353	18·4	36·8	55·2	73·6	92·0	110·4	128·8	147·2	165·6
2366	18·3	36·6	54·9	73·2	91·5	109·8	128·1	146·4	164·7
2379	18·2	36·4	54·6	72·8	91·0	109·2	127·4	145·6	163·8
2392	18·1	36·2	54·3	72·4	90·5	108·6	126·7	144·8	162·9
2406	18·0	36·0	54·0	72·0	90·0	108·0	126·0	144·0	162·0
2419	17·9	35·8	53·7	71·6	89·5	107·4	125·3	143·2	161·1

No. 240 L. 380.] LOGARITHMS OF NUMBERS. [No. 269 L. 431.

N.	0	1	2	3	4	5	6	7	8	9	N.
240	380211	0392	0573	0754	0934	1115	1296	1476	1656	1837	240
1	2017	2197	2377	2557	2737	2917	3097	3277	3456	3636	1
2	3815	3995	4174	4353	4533	4712	4891	5070	5249	5428	2
3	5606	5785	5964	6142	6321	6499	6677	6856	7034	7212	3
4	7390	7568	7746	7924	8101	8279	8456	8634	8811	8989	4
5	9166	9343	9520	9698	9875	0051	0228	0405	0582	0759	5
6	390935	1112	1288	1464	1641	1817	1993	2169	2345	2521	6
7	2697	2873	3048	3224	3400	3575	3751	3926	4101	4277	7
8	4452	4627	4802	4977	5152	5326	5501	5676	5850	6025	8
9	6199	6374	6548	6722	6896	7071	7245	7419	7592	7766	9
250	7940	8114	8287	8461	8634	8808	8981	9154	9328	9501	250
1	9674	9847	0020	0192	0365	0538	0711	0883	1056	1228	1
2	401401	1573	1745	1917	2089	2261	2433	2605	2777	2949	2
3	3121	3292	3464	3635	3807	3978	4149	4320	4492	4663	3
4	4834	5005	5176	5346	5517	5688	5858	6029	6199	6370	4
5	6540	6710	6881	7051	7221	7391	7561	7731	7901	8070	5
6	8240	8410	8579	8749	8918	9087	9257	9426	9595	9764	6
7	9933	0102	0271	0440	0609	0777	0946	1114	1283	1451	7
8	411620	1788	1956	2124	2293	2461	2629	2796	2964	3132	8
9	3300	3467	3635	3803	3970	4137	4305	4472	4639	4806	9
260	4973	5140	5307	5474	5641	5808	5974	6141	6308	6474	260
1	6641	6807	6973	7139	7306	7472	7638	7804	7970	8135	1
2	8301	8467	8633	8798	8964	9129	9295	9460	9625	9791	2
3	9956	0121	0286	0451	0616	0781	0945	1110	1275	1439	3
4	421604	1768	1933	2097	2261	2426	2590	2754	2918	3082	4
5	3246	3410	3574	3737	3901	4065	4228	4392	4555	4718	5
6	4882	5045	5208	5371	5534	5697	5860	6023	6186	6349	6
7	6511	6674	6836	6999	7161	7324	7486	7648	7811	7973	7
8	8135	8297	8459	8621	8783	8944	9106	9268	9429	9591	8
9	9752	9914	0075	0236	0398	0559	0720	0881	1042	1203	9

PROPORTIONAL PARTS.

N.	1	2	3	4	5	6	7	8	9
2433	17·8	35·6	53·4	71·2	89·0	106·8	124·6	142·4	160·2
2446	17·7	35·4	53·1	70·8	88·5	106·2	123·9	141·6	159·3
2460	17·6	35·2	52·8	70·4	88·0	105·6	123·2	140·8	158·4
2474	17·5	35·0	52·5	70·0	87·5	105·0	122·5	140·0	157·5
2488	17·4	34·8	52·2	69·6	87·0	104·4	121·8	139·2	156·6
2503	17·3	34·6	51·9	69·2	86·5	103·8	121·1	138·4	155·7
2517	17·2	34·4	51·6	68·8	86·0	103·2	120·4	137·6	154·8
2532	17·1	34·2	51·3	68·4	85·5	102·6	119·7	136·8	153·9
2547	17·0	34·0	51·0	68·0	85·0	102·0	119·0	136·0	153·0
2562	16·9	33·8	50·7	67·6	84·5	101·4	118·3	135·2	152·1
2577	16·8	33·6	50·4	67·2	84·0	100·8	117·6	134·4	151·2
2592	16·7	33·4	50·1	66·8	83·5	100·2	116·9	133·6	150·3
2608	16·6	33·2	49·8	66·4	83·0	99·6	116·2	132·8	149·4
2624	16·5	33·0	49·5	66·0	82·5	99·0	115·5	132·0	148·5
2640	16·4	32·8	49·2	65·6	82·0	98·4	114·8	131·2	147·6
2656	16·3	32·6	48·9	65·2	81·5	97·8	114·1	130·4	146·7
2672	16·2	32·4	48·5	64·8	81·0	97·2	113·4	129·6	145·8
2689	16·1	32·2	48·3	64·4	80·5	96·6	112·7	128·8	144 9

No. 270 L 431.] LOGARITHMS OF NUMBERS. [No. 299 L. 476.

N.	0	1	2	3	4	5	6	7	8	9	N.
270	431364	1525	1685	1846	2007	2167	2328	2488	2649	2809	270
1	2969	3130	3290	3450	3610	3770	3930	4090	4249	4409	1
2	4569	4729	4888	5048	5207	5367	5526	5685	5844	6004	2
3	6163	6322	6481	6640	6799	6957	7116	7275	7433	7592	3
4	7751	7909	8067	8226	8384	8542	8701	8859	9017	9175	4
5	9333	9491	9648	9806	9964	0122	0279	0437	0594	0752	5
6	440909	1066	1224	1381	1538	1695	1852	2009	2166	2323	6
7	2480	2637	2793	2950	3106	3263	3419	3576	3732	3889	7
8	4045	4201	4357	4513	4669	4825	4981	5137	5293	5449	8
9	5604	5760	5915	6071	6226	6382	6537	6692	6848	7003	9
280	7158	7313	7468	7623	7778	7933	8088	8242	8397	8552	280
1	8706	8861	9015	9170	9324	9478	9633	9787	9941	0095	1
2	450249	0403	0557	0711	0865	1018	1172	1326	1479	1633	2
3	1786	1940	2093	2247	2400	2553	2706	2859	3012	3165	3
4	3318	3471	3624	3777	3930	4082	4235	4387	4540	4692	4
5	4845	4997	5150	5302	5454	5606	5758	5910	6062	6214	5
6	6366	6518	6670	6821	6973	7125	7276	7428	7579	7731	6
7	7882	8033	8184	8336	8487	8638	8789	8940	9091	9242	7
8	9392	9543	9694	9845	9995	0146	0296	0447	0597	0748	8
9	460898	1048	1198	1348	1499	1649	1799	1948	2098	2248	9
290	2398	2548	2697	2847	2997	3146	3296	3445	3594	3744	290
1	3893	4042	4191	4340	4490	4639	4788	4936	5085	5234	1
2	5383	5532	5680	5829	5977	6126	6274	6423	6571	6719	2
3	6868	7016	7164	7312	7460	7608	7756	7904	8052	8200	3
4	8347	8495	8643	8790	8938	9085	9233	9380	9527	9675	4
5	9822	9969	0116	0263	0410	0557	0704	0851	0998	1145	5
6	471292	1438	1585	1732	1878	2025	2171	2318	2464	2610	6
7	2756	2903	3049	3195	3341	3487	3633	3779	3925	4071	7
8	4216	4362	4508	4653	4799	4944	5090	5235	5381	5526	8
9	5671	5816	5962	6107	6252	6397	6542	6687	6832	6976	9

PROPORTIONAL PARTS.

N.	1	2	3	4	5	6	7	8	9
2705	16·0	32·0	48·0	64·0	80·0	96·0	112·0	128·0	144·0
2722	15·9	31·8	47·7	63·6	79·5	95·4	111·3	127·2	143·1
2740	15·8	31·6	47·4	63·2	79·0	94·8	110·6	126·4	142·2
2757	15·7	31·4	47·1	62·8	78·5	94·2	109·9	125·6	141·3
2775	15·6	31·2	46·8	62·4	78·0	93·6	109·2	124·8	140·4
2792	15·5	31·0	46·5	62·0	77·5	93·0	108·5	124·0	139·5
2810	15·4	30·8	46·2	61·6	77·0	92·4	107·8	123·2	138·6
2833	15·3	30·6	45·9	61·2	76·5	91·8	107·1	122·4	137·7
2847	15·2	30·4	45·6	60·8	76·0	91·2	106·4	121·6	136·8
2866	15·1	30·2	45·3	60·4	75·5	90·6	105·7	120·8	135·9
2885	15·0	30·0	45·0	60·0	75·0	90·0	105·0	120·0	135·0
2904	14·9	29·8	44·7	59·6	74·5	89·4	104·3	119·2	134·1
2924	14·8	29·6	44·4	59·2	74·0	88·8	103·6	118·4	133·2
2944	14·7	29·4	44·1	58·8	73·5	88·2	102·9	117·6	132·3
2964	14·6	29·2	43·8	58·4	73·0	87·6	102·2	116·8	131·4
2984	14·5	29·0	43·5	58·0	72·5	87·0	101·5	116·0	130·5
3005	14·4	28·8	43·2	57·6	72·0	86·4	100·8	115·2	129·6
3026	14·3	28·6	42·9	57·2	71·5	85·8	100·1	114·4	128·7
3047	14·2	28·4	42·6	56·8	71·0	85·2	99·4	113·6	127·8
3069	14·1	28·2	42·3	56·4	70·5	84·6	98·7	112·8	126·9
3091	14·0	28·0	42·0	56·0	70·0	84·0	98·0	112·0	126·0

No. 300 L. 477.]				LOGARITHMS OF NUMBERS.						[No. 339 L. 531.	
N.	0	1	2	3	4	5	6	7	8	9	N.
300	477121	7266	7411	7555	7700	7844	7989	8133	8278	8422	300
1	8566	8711	8855	8999	9143	9287	9431	9575	9719	9863	1
2	480007	0151	0294	0438	0582	0725	0869	1012	1156	1299	2
3	1443	1586	1729	1872	2016	2159	2302	2445	2588	2731	3
4	2874	3016	3159	3302	3445	3587	3730	3872	4015	4157	4
5	4300	4442	4585	4727	4869	5011	5153	5295	5437	5579	5
6	5721	5863	6005	6147	6289	6430	6572	6714	6855	6997	6
7	7138	7280	7421	7563	7704	7845	7986	8127	8269	8410	7
8	8551	8692	8833	8974	9114	9255	9396	9537	9677	9818	8
9	9958	0099	0239	0380	0520	0661	0801	0941	1081	1222	9
310	491362	1502	1642	1782	1922	2062	2201	2341	2481	2621	310
1	2760	2900	3040	3179	3319	3458	3597	3737	3876	4015	1
2	4155	4294	4433	4572	4711	4850	4989	5128	5267	5406	2
3	5544	5683	5822	5960	6099	6238	6376	6515	6653	6791	3
4	6930	7068	7206	7344	7483	7621	7759	7897	8035	8173	4
5	8311	8448	8586	8724	8862	8999	9137	9275	9412	9550	5
6	9687	9824	9962	0099	0236	0374	0511	0648	0785	0922	6
7	501059	1196	1333	1470	1607	1744	1880	2017	2154	2291	7
8	2427	2564	2700	2837	2973	3109	3246	3382	3518	3655	8
9	3791	3927	4063	4199	4335	4471	4607	4743	4878	5014	9
320	5150	5286	5421	5557	5693	5828	5964	6099	6234	6370	320
1	6505	6640	6776	6911	7046	7181	7316	7451	7586	7721	1
2	7856	7991	8126	8260	8395	8530	8664	8799	8934	9068	2
3	9203	9337	9471	9606	9740	9874	0009	0143	0277	0411	3
4	510545	0679	0813	0947	1081	1215	1349	1482	1616	1750	4
5	1883	2017	2151	2284	2418	2551	2684	2818	2951	3084	5
6	3218	3351	3484	3617	3750	3883	4016	4149	4282	4415	6
7	4548	4681	4813	4946	5079	5211	5344	5476	5609	5741	7
8	5874	6006	6139	6271	6403	6535	6668	6800	6932	7064	8
9	7196	7328	7460	7592	7724	7855	7987	8119	8251	8382	9
330	8514	8646	8777	8909	9040	9171	9303	9434	9566	9697	330
1	9828	9959	0090	0221	0353	0485	0615	0745	0876	1007	1
2	521138	1269	1400	1530	1661	1792	1922	2053	2183	2314	2
3	2444	2575	2705	2835	2966	3096	3226	3356	3486	3616	3
4	3746	3876	4006	4136	4266	4396	4526	4656	4785	4915	4
5	5045	5174	5304	5434	5563	5693	5822	5951	6081	6210	5
6	6339	6469	6598	6727	6856	6985	7114	7243	7372	7501	6
7	7630	7759	7888	8016	8145	8274	8402	8531	8660	8788	7
8	8917	9045	9174	9302	9430	9559	9687	9815	9943	0072	8
9	530200	0328	0456	0584	0712	0840	0968	1096	1223	1351	9

PROPORTIONAL PARTS.									
N.	1	2	3	4	5	6	7	8	9
3113	13·9	27·8	41·7	55·6	69·5	83·4	97·3	111·2	125·1
3135	13·8	27·6	41·4	55·2	69·0	82·8	96·6	110·4	124·2
3158	13·7	27·4	41·1	54·8	68·5	82·2	95·9	109·6	123·3
3181	13·6	27·2	40·8	54·4	68·0	81·6	95·2	108·8	122·4
3205	13·5	27·0	40·5	54·0	67·5	81·0	94·5	108·0	121·5
3228	13·4	26·8	40·2	53·6	67·0	80·4	93·8	107·2	120·6
3253	13·3	26·6	39·9	53·2	66·5	79·8	93·1	106·4	119·7
3277	13·2	26·4	39·6	52·8	66·0	79·2	92·4	105·6	118·8
3302	13·1	26·2	39·3	52·4	65·5	78·6	91·7	104·8	117·9
3327	13·0	26·0	39·0	52·0	65·0	78·0	91·0	104·0	117·0
3353	12·9	25·8	38·7	51·6	64·5	77·4	90·3	103·2	116·1

No. 340 L. 531.]	LOGARITHMS OF NUMBERS.									[No. 379 L. 579.	
N.	0	1	2	3	4	5	6	7	8	9	N.
340	531479	1607	1734	1862	1990	2117	2245	2372	2500	2627	340
1	2754	2882	3009	3136	3264	3391	3518	3645	3772	3899	1
2	4026	4153	4280	4407	4534	4661	4787	4914	5041	5167	2
3	5294	5421	5547	5674	5800	5927	6053	6179	6306	6432	3
4	6558	6685	6811	6937	7063	7189	7315	7441	7567	7693	4
5	7819	7945	8071	8197	8322	8448	8574	8699	8825	8951	5
6	9076	9202	9327	9452	9578	9703	9829	9954	0079	0204	6
7	540329	0455	0580	0705	0830	0955	1080	1205	1330	1454	7
8	1579	1704	1829	1953	2078	2203	2327	2452	2576	2701	8
9	2825	2950	3074	3199	3323	3447	3571	3696	3820	3944	9
350	4068	4192	4316	4440	4564	4688	4812	4936	5060	5183	350
1	5307	5431	5555	5678	5802	5925	6049	6172	6296	6419	1
2	6543	6666	6789	6913	7036	7159	7282	7405	7529	7652	2
3	7775	7898	8021	8144	8267	8389	8512	8635	8758	8881	3
4	9003	9126	9249	9371	9494	9616	9739	9861	9984	0106	4
5	550228	0351	0473	0595	0717	0840	0962	1084	1206	1328	5
6	1450	1572	1694	1816	1938	2060	2181	2303	2425	2547	6
7	2668	2790	2911	3033	3155	3276	3398	3519	3640	3762	7
8	3883	4004	4126	4247	4368	4489	4610	4731	4852	4973	8
9	5094	5215	5336	5457	5578	5699	5820	5940	6061	6182	9
360	6303	6423	6544	6664	6785	6905	7026	7146	7267	7387	360
1	7507	7627	7748	7868	7988	8108	8228	8349	8469	8589	1
2	8709	8829	8948	9068	9188	9308	9428	9548	9667	9787	2
3	9907	0026	0146	0265	0385	0504	0624	0743	0863	0982	3
4	561101	1221	1340	1459	1578	1698	1817	1936	2055	2174	4
5	2293	2412	2531	2650	2769	2887	3006	3125	3244	3362	5
6	3481	3600	3718	3837	3955	4074	4192	4311	4429	4548	6
7	4666	4784	4903	5021	5139	5257	5376	5494	5612	5730	7
8	5848	5966	6084	6202	6320	6437	6555	6673	6791	6909	8
9	7026	7144	7262	7379	7497	7614	7732	7849	7967	8084	9
370	8202	8319	8436	8554	8671	8788	8905	9023	9140	9257	370
1	9374	9491	9608	9725	9842	9959	0076	0193	0309	0426	1
2	570543	0660	0776	0893	1010	1126	1243	1359	1476	1592	2
3	1709	1825	1942	2058	2174	2291	2407	2523	2639	2755	3
4	2872	2988	3104	3220	3336	3452	3568	3684	3800	3915	4
5	4031	4147	4263	4379	4494	4610	4726	4841	4957	5072	5
6	5188	5303	5419	5534	5650	5765	5880	5996	6111	6226	6
7	6341	6457	6572	6687	6802	6917	7032	7147	7262	7377	7
8	7492	7607	7722	7836	7951	8066	8181	8295	8410	8525	8
9	8639	8754	8868	8983	9097	9212	9326	9441	9555	9669	9

PROPORTIONAL PARTS.	N.	1	2	3	4	5	6	7	8	9
	3379	12·8	25·6	38·4	51·2	64·0	76·8	89·6	102·4	115·2
	3406	12·7	25·4	38·1	50·8	63·5	76·2	88·9	101·6	114·3
	3433	12·6	25·2	37·8	50·4	63·0	75·6	88·2	100·8	113·4
	3460	12·5	25·0	37·5	50·0	62·5	75·0	87·5	100·0	112·5
	3488	12·4	24·8	37·2	49·6	62·0	74·4	86·8	99·2	111·6
	3516	12·3	24·6	36·9	49·2	61·5	73·8	86·1	98·4	110·7
	3545	12·2	24·4	36·6	48·8	61·0	73·2	85·4	97·6	109·8
	3574	12·1	24·2	36·3	48·4	60·5	72·6	84·7	96·8	108·9
	3604	12·0	24·0	36·0	48·0	60·0	72·0	84·0	96·0	108·0
	3634	11·9	23·8	35·7	47·6	59·5	71·4	83·3	95·2	107·1

No. 380 L. 579.]				LOGARITHMS OF NUMBERS.						[No. 414 L. 617.	
N.	0	1	2	3	4	5	6	7	8	9	N.
380	579784	9898	0012	0126	0241	0355	0469	0583	0697	0811	380
1	580925	1039	1153	1267	1381	1495	1608	1722	1836	1950	1
2	2063	2177	2291	2404	2518	2631	2745	2858	2972	3085	2
3	3199	3312	3426	3539	3652	3765	3879	3992	4105	4218	3
4	4331	4444	4557	4670	4783	4896	5009	5122	5235	5348	4
5	5461	5574	5686	5799	5912	6024	6137	6250	6362	6475	5
6	6587	6700	6812	6925	7037	7149	7262	7374	7486	7599	6
7	7711	7823	7935	8047	8160	8272	8384	8496	8608	8720	7
8	8832	8944	9056	9167	9279	9391	9503	9615	9726	9838	8
9	9950	0061	0173	0284	0396	0507	0619	0730	0842	0953	9
390	591065	1176	1287	1399	1510	1621	1732	1843	1955	2066	390
1	2177	2288	2399	2510	2621	2732	2843	2954	3064	3175	1
2	3286	3397	3508	3618	3729	3840	3950	4061	4171	4282	2
3	4393	4503	4614	4724	4834	4945	5055	5165	5276	5386	3
4	5496	5606	5717	5827	5937	6047	6157	6267	6377	6487	4
5	6597	6707	6817	6927	7037	7146	7256	7366	7476	7586	5
6	7695	7805	7914	8024	8134	8243	8353	8462	8572	8681	6
7	8791	8900	9009	9119	9228	9337	9446	9556	9665	9774	7
8	9883	9992	0101	0210	0319	0428	0537	0646	0755	0864	8
9	600973	1082	1191	1299	1408	1517	1625	1734	1843	1951	9
400	2060	2169	2277	2386	2494	2603	2711	2819	2928	3036	400
1	3144	3253	3361	3469	3577	3686	3794	3902	4010	4118	1
2	4226	4334	4442	4550	4658	4766	4874	4982	5089	5197	2
3	5305	5413	5521	5628	5736	5844	5951	6059	6166	6274	3
4	6381	6489	6596	6704	6811	6919	7026	7133	7241	7348	4
5	7455	7562	7669	7777	7884	7991	8098	8205	8312	8419	5
6	8526	8633	8740	8847	8954	9061	9167	9274	9381	9488	6
7	9594	9701	9808	9914	0021	0128	0234	0341	0447	0554	7
8	610660	0767	0873	0979	1086	1192	1298	1405	1511	1617	8
9	1723	1829	1936	2042	2148	2254	2360	2466	2572	2678	9
10	2784	2890	2996	3102	3207	3313	3419	3525	3630	3736	410
1	3842	3947	4053	4159	4264	4370	4475	4581	4686	4792	1
2	4897	5003	5108	5213	5319	5424	5529	5634	5740	5845	2
3	5950	6055	6160	6265	6370	6476	6581	6686	6790	6895	3
4	7000	7105	7210	7315	7420	7525	7629	7734	7839	7943	4

PROPORTIONAL PARTS.										
N.	1	2	3	4	5	6	7	8	9	
3665	11·8	23·6	35·4	47·2	59·0	70·8	82·6	94·4	106·2	
3696	11·7	23·4	35·1	46·8	58·5	70·2	81·9	93·6	105·3	
3727	11·6	23·2	34·8	46·4	58·0	69·6	81·2	92·8	104·4	
3760	11·5	23·0	34·5	46·0	57·5	69·0	80·5	92·0	103·5	
3792	11·4	22·8	34·2	45·6	57·0	68·4	79·8	91·2	102·6	
3826	11·3	22·6	33·9	45·2	56·5	67·8	79·1	90·4	101·7	
3860	11·2	22·4	33·6	44·8	56·0	67·2	78·4	89·6	100·8	
3895	11·1	22·2	33·3	44·4	55·5	66·6	77·7	88·8	99·9	
3930	11·0	22·0	33·0	44·0	55·0	66·0	77·0	88·0	99·0	
3966	10·9	21·8	32·7	43·6	54·5	65·4	76·3	87·2	98·1	
4002	10·8	21·6	32·4	43·2	54·0	64·8	75·6	86·4	97·2	
4039	10·7	21·4	32·1	42·8	53·5	64·2	74·9	85·6	96·3	
4077	10·6	21·2	31·8	42·4	53·0	63·6	74·2	84·8	95·4	
4116	10·5	21·0	31·5	42·0	52·5	63·0	73·5	84·0	94·5	

No. 415 L. 618.]	LOGARITHMS OF NUMBERS.									[No. 459 L. 662.	
N.	0	1	2	3	4	5	6	7	8	9	N.
415	618048	8153	8257	8362	8466	8571	8676	8780	8884	8989	415
6	9093	9198	9302	9406	9511	9615	9719	9824	9928	0032	6
7	620136	0240	0344	0448	0552	0656	0760	0864	0968	1072	7
8	1176	1280	1384	1488	1592	1695	1799	1903	2007	2110	8
9	2214	2318	2421	2525	2628	2732	2835	2939	3042	3146	9
420	3249	3353	3456	3559	3663	3766	3869	3973	4076	4179	420
1	4282	4385	4488	4591	4695	4798	4901	5004	5107	5210	1
2	5312	5415	5518	5621	5724	5827	5929	6032	6135	6238	2
3	6340	6443	6546	6648	6751	6853	6956	7058	7161	7263	3
4	7366	7468	7571	7673	7775	7878	7980	8082	8185	8287	4
5	8389	8491	8593	8695	8797	8900	9002	9104	9206	9308	5
6	9410	9512	9613	9715	9817	9919	0021	0123	0224	0326	6
7	630428	0530	0631	0733	0835	0936	1038	1139	1241	1342	7
8	1444	1545	1647	1748	1849	1951	2052	2153	2255	2356	8
9	2457	2559	2660	2761	2862	2963	3064	3165	3266	3367	9
430	3468	3569	3670	3771	3872	3973	4074	4175	4276	4376	430
1	4477	4578	4679	4779	4880	4981	5081	5182	5283	5383	1
2	5484	5584	5685	5785	5886	5986	6087	6187	6287	6388	2
3	6488	6588	6688	6789	6889	6989	7089	7189	7290	7390	3
4	7490	7590	7690	7790	7890	7990	8090	8190	8290	8389	4
5	8489	8589	8689	8789	8888	8988	9088	9188	9287	9387	5
6	9486	9586	9686	9785	9885	9984	0084	0183	0283	0382	6
7	640481	0581	0680	0779	0879	0978	1077	1177	1276	1375	7
8	1474	1573	1672	1771	1871	1970	2069	2168	2267	2306	8
9	2465	2563	2662	2761	2860	2959	3058	3156	3255	3354	9
440	3453	3551	3650	3749	3847	3946	4044	4143	4242	4340	440
1	4439	4537	4636	4734	4832	4931	5029	5127	5226	5324	1
2	5422	5521	5619	5717	5815	5913	6011	6110	6208	6306	2
3	6404	6502	6600	6698	6796	6894	6992	7089	7187	7285	3
4	7383	7481	7579	7676	7774	7872	7969	8067	8165	8262	4
5	8360	8458	8555	8653	8750	8848	8945	9043	9140	9237	5
6	9335	9432	9530	9627	9724	9821	9919	0016	0113	0210	6
7	650308	0405	0502	0599	0696	0793	0890	0987	1084	1181	7
8	1278	1375	1472	1569	1666	1762	1859	1956	2053	2150	8
9	2246	2343	2440	2536	2633	2730	2826	2923	3019	3116	9
450	3213	3309	3405	3502	3598	3695	3791	3888	3984	4080	450
1	4177	4273	4369	4465	4562	4658	4754	4850	4946	5042	1
2	5138	5235	5331	5427	5523	5619	5715	5810	5906	6002	2
3	6098	6194	6290	6386	6482	6577	6673	6769	6864	6960	3
4	7056	7152	7247	7343	7438	7534	7629	7725	7820	7916	4
5	8011	8107	8202	8298	8393	8488	8584	8679	8774	8870	5
6	8965	9060	9155	9250	9346	9441	9536	9631	9726	9821	6
7	9916	0011	0106	0201	0296	0391	0486	0581	0676	0771	7
8	660865	0960	1055	1150	1245	1339	1434	1529	1623	1718	8
9	1813	1907	2002	2096	2191	2286	2380	2475	2569	2663	9

PROPORTIONAL PARTS.									
N.	1	2	3	4	5	6	7	8	9
4155	10·4	20·8	31·2	41·6	52·0	62·4	72·8	83·2	93·6
4196	10·3	20·6	30·9	41·2	51·5	61·8	72·1	82·4	92·7
4237	10·2	20·4	30·6	40·8	51·0	61·2	71·4	81·6	91·8
4278	10·1	20·2	30·3	40·4	50·5	60·6	70·7	80·8	90·9
4321	10·0	20·0	30·0	40·0	50·0	60·0	70·0	80·0	90·0
4364	9·9	19·8	29·7	39·6	49·5	59·4	69·3	79·2	89·1

No. 460 L. 662.]	LOGARITHMS OF NUMBERS.									[No. 499 L. 698.	
N.	0	1	2	3	4	5	6	7	8	9	N.
460	662758	2852	2947	3041	3135	3230	3324	3418	3512	3607	460
1	3701	3795	3889	3983	4078	4172	4266	4360	4454	4548	1
2	4642	4736	4830	4924	5018	5112	5206	5299	5393	5487	2
3	5581	5675	5769	5862	5956	6050	6143	6237	6331	6424	3
4	6518	6612	6705	6799	6892	6986	7079	7173	7266	7360	4
5	7453	7546	7640	7733	7826	7920	8013	8106	8199	8293	5
6	8386	8479	8572	8665	8759	8852	8945	9038	9131	9224	6
7	9317	9410	9503	9596	9689	9782	9875	9967	0060	0153	7
8	670246	0339	0431	0524	0617	0710	0802	0895	0988	1080	8
9	1173	1265	1358	1451	1543	1636	1728	1821	1913	2005	9
470	2098	2190	2283	2375	2467	2560	2652	2744	2836	2929	470
1	3021	3113	3205	3297	3390	3482	3574	3666	3758	3850	1
2	3942	4034	4126	4218	4310	4402	4494	4586	4677	4769	2
3	4861	4953	5045	5137	5228	5320	5412	5503	5595	5687	3
4	5778	5870	5962	6053	6145	6236	6328	6419	6511	6602	4
5	6694	6785	6876	6968	7059	7151	7242	7333	7424	7516	5
6	7607	7698	7789	7881	7972	8063	8154	8245	8336	8427	6
7	8518	8609	8700	8791	8882	8973	9064	9155	9246	9337	7
8	9428	9519	9610	9700	9791	9882	9973	0063	0154	0245	8
9	680336	0426	0517	0607	0698	0789	0879	0970	1060	1151	9
480	1241	1332	1422	1513	1603	1693	1784	1874	1964	2055	480
1	2145	2235	2326	2416	2506	2596	2686	2777	2867	2957	1
2	3047	3137	3227	3317	3407	3497	3587	3677	3767	3857	2
3	3947	4037	4127	4217	4307	4396	4486	4576	4666	4756	3
4	4845	4935	5025	5114	5204	5294	5383	5473	5563	5652	4
5	5742	5831	5921	6010	6100	6189	6279	6368	6458	6547	5
6	6636	6726	6815	6904	6994	7083	7172	7261	7351	7440	6
7	7529	7618	7707	7796	7886	7975	8064	8153	8242	8331	7
8	8420	8509	8598	8687	8776	8865	8953	9042	9131	9220	8
9	9309	9398	9486	9575	9664	9753	9841	9930	0019	0107	9
490	690196	0285	0373	0462	0550	0639	0728	0816	0905	0993	490
1	1081	1170	1258	1347	1435	1524	1612	1700	1789	1877	1
2	1965	2053	2142	2230	2318	2406	2494	2583	2671	2759	2
3	2847	2935	3023	3111	3199	3287	3375	3463	3551	3639	3
4	3727	3815	3903	3991	4078	4166	4254	4342	4430	4517	4
5	4605	4693	4781	4868	4956	5044	5131	5219	5307	5394	5
6	5482	5569	5657	5744	5832	5919	6007	6094	6182	6269	6
7	6356	6444	6531	6618	6706	6793	6880	6968	7055	7142	7
8	7229	7317	7404	7491	7578	7665	7752	7839	7926	8014	8
9	8100	8188	8275	8362	8449	8535	8622	8709	8796	8883	9

PROPORTIONAL PARTS.	N.	1	2	3	4	5	6	7	8	9
	4410	9·8	19·6	29·4	39·2	49·0	58·8	68·6	78·4	88·2
	4454	9·7	19·4	29·1	38·8	48·5	58·2	67·9	77·6	87·3
	4500	9·6	19·2	28·8	38·4	48·0	57·6	67·2	76·8	86·4
	4547	9·5	19·0	28·5	38·0	47·5	57·0	66·5	76·0	85·5
	4595	9·4	18·8	28·2	37·6	47·0	56·4	65·8	75·2	84·6
	4644	9·3	18·6	27·9	37·2	46·5	55·8	65·1	74·4	83·7
	4695	9·2	18·4	27·6	36·8	46·0	55·2	64·4	73·6	82.8
	4746	9·1	18·2	27·3	36·4	45·5	54·6	63·7	72·8	81·9
	4798	9·0	18·0	27·0	36·0	45·0	54·0	63·0	72·0	81·0
	4852	8.9	17·8	26·7	35·6	44·5	53·4	62·3	71·2	80·1
	4907	8·8	17·6	26·4	35·2	44·0	52·8	61·6	70·4	79·2

No. 500 L. 698.]	LOGARITHMS OF NUMBERS.									[No. 544 L. 736.	
N.	0	1	2	3	4	5	6	7	8	9	N.
500	698970	9057	9144	9231	9317	9404	9491	9578	9664	9751	500
1	9838	9924	0011	0098	0184	0271	0358	0444	0531	0617	1
2	700704	0790	0877	0963	1050	1136	1222	1309	1395	1482	2
3	1568	1654	1741	1827	1913	1999	2086	2172	2258	2344	3
4	2431	2517	2603	2689	2775	2861	2947	3033	3119	3205	4
5	3291	3377	3463	3549	3635	3721	3807	3893	3979	4065	5
6	4151	4236	4322	4408	4494	4579	4665	4751	4837	4922	6
7	5008	5094	5179	5265	5350	5436	5522	5607	5693	5778	7
8	5864	5949	6035	6120	6206	6291	6376	6462	6547	6632	8
9	6718	6803	6888	6974	7059	7144	7229	7315	7400	7485	9
510	7570	7655	7740	7826	7911	7996	8081	8166	8251	8336	510
1	8421	8506	8591	8676	8761	8846	8931	9015	9100	9185	1
2	9270	9355	9440	9524	9609	9694	9779	9863	9948	0033	2
3	710117	0202	0287	0371	0456	0540	0625	0710	0794	0879	3
4	0963	1048	1132	1217	1301	1385	1470	1554	1639	1723	4
5	1807	1892	1976	2060	2144	2229	2313	2397	2481	2566	5
6	2650	2734	2818	2902	2986	3070	3154	3238	3323	3407	6
7	3491	3575	3659	3742	3826	3910	3994	4078	4162	4246	7
8	4330	4414	4497	4581	4665	4749	4833	4916	5000	5084	8
9	5167	5251	5335	5418	5502	5586	5669	5753	5836	5920	9
520	6003	6087	6170	6254	6337	6421	6504	6588	6671	6754	520
1	6838	6921	7004	7088	7171	7254	7338	7421	7504	7587	1
2	7671	7754	7837	7920	8003	8086	8169	8253	8336	8419	2
3	8502	8585	8668	8751	8834	8917	9000	9083	9165	9248	3
4	9331	9414	9497	9580	9663	9745	9828	9911	9994	0077	4
5	720159	0242	0325	0407	0490	0573	0655	0738	0821	0903	5
6	0986	1068	1151	1233	1316	1398	1481	1563	1646	1728	6
7	1811	1893	1975	2058	2140	2222	2305	2387	2469	2552	7
8	2634	2716	2798	2881	2963	3045	3127	3209	3291	3374	8
9	3456	3538	3620	3702	3784	3866	3948	4030	4112	4194	9
530	4276	4358	4440	4522	4604	4685	4767	4849	4931	5013	530
1	5095	5176	5258	5340	5422	5503	5585	5667	5748	5830	1
2	5912	5993	6075	6156	6238	6320	6401	6483	6564	6646	2
3	6727	6809	6890	6972	7053	7134	7216	7297	7379	7460	3
4	7541	7623	7704	7785	7866	7948	8029	8110	8191	8273	4
5	8354	8435	8516	8597	8678	8759	8841	8922	9003	9084	5
6	9165	9246	9327	9408	9489	9570	9651	9732	9813	9893	6
7	9974	0055	0136	0217	0298	0378	0459	0540	0621	0702	7
8	730782	0863	0944	1024	1105	1186	1266	1347	1428	1508	8
9	1589	1669	1750	1830	1911	1991	2072	2152	2233	2313	9
540	2394	2474	2555	2635	2715	2796	2876	2956	3037	3117	540
1	3197	3278	3358	3438	3518	3598	3679	3759	3839	3919	1
2	3999	4079	4160	4240	4320	4400	4480	4560	4640	4720	2
3	4800	4880	4960	5040	5120	5199	5279	5359	5439	5519	3
4	5599	5679	5759	5838	5918	5998	6078	6157	6237	6317	4

PROP. PARTS.	N.	1	2	3	4	5	6	7	8	9
	4963	8·7	17·4	26·1	34·8	43·5	52·2	60·9	69·6	78·3
	5020	8·6	17·2	25·8	34·4	43·0	51·6	60·2	68·8	77·4
	5079	8·5	17·0	25·5	34·0	42·5	51·0	59·5	68·0	76·5
	5139	8·4	16·8	25·2	33·6	42·0	50·4	58·8	67·2	75·6

No. 545 L. 736.]	LOGARITHMS OF NUMBERS.									[No. 584 L. 767.	
N.	0	1	2	3	4	5	6	7	8	9	N.
545	736397	6476	6556	6635	6715	6795	6874	6954	7034	7113	545
6	7193	7272	7552	7431	7511	7590	7670	7749	7829	7908	6
7	7987	8067	8146	8225	8305	8384	8463	8543	8622	8701	7
8	8781	8860	8959	9018	9097	9177	9256	9335	9414	9493	8
9	9572	9651	9731	9810	9889	9968	0047	0126	0205	0284	9
550	740363	0442	0521	0600	0678	0757	0836	0915	0994	1073	550
1	1152	1230	1309	1388	1467	1546	1624	1703	1782	1860	1
2	1939	2018	2096	2175	2254	2332	2411	2489	2568	2647	2
3	2725	2804	2882	2961	3039	3118	3196	3275	3353	3431	3
4	3510	3588	3667	3745	3823	3902	3980	4058	4136	4215	4
5	4293	4371	4449	4528	4606	4684	4762	4840	4919	4997	5
6	5075	5153	5231	5309	5387	5465	5543	5621	5699	5777	6
7	5855	5933	6011	6089	6167	6245	6323	6401	6479	6556	7
8	6634	6712	6790	6868	6945	7023	7101	7179	7256	7334	8
9	7412	7489	7567	7645	7722	7800	7878	7955	8033	8110	9
560	8188	8266	8343	8421	8498	8576	8653	8731	8808	8885	560
1	8963	9040	9118	9195	9272	9350	9427	9504	9582	9659	1
2	9736	9814	9891	9968	0045	0123	0200	0277	0354	0431	2
3	750508	0586	0663	0740	0817	0894	0971	1048	1125	1202	3
4	1279	1356	1433	1510	1587	1664	1741	1818	1895	1972	4
5	2048	2125	2202	2279	2356	2433	2509	2586	2663	2740	5
6	2816	2893	2970	3047	3123	3200	3277	3353	3430	3506	6
7	3583	3660	3736	3813	3889	3966	4042	4119	4195	4272	7
8	4348	4425	4501	4578	4654	4730	4807	4883	4960	5036	8
9	5112	5189	5265	5341	5417	5494	5570	5646	5722	5799	9
570	5875	5951	6027	6103	6180	6256	6332	6408	6484	6560	570
1	6636	6712	6788	6864	6940	7016	7092	7168	7244	7320	1
2	7396	7472	7548	7624	7700	7775	7851	7927	8003	8079	2
3	8155	8230	8306	8382	8458	8533	8609	8685	8761	8836	3
4	8912	8988	9063	9139	9214	9290	9366	9441	9517	9592	4
5	9668	9743	9819	9894	9970	0045	0121	0196	0272	0347	5
6	760422	0498	0573	0649	0724	0799	0875	0950	1025	1101	6
7	1176	1251	1326	1402	1477	1552	1627	1702	1778	1853	7
8	1928	2003	2078	2153	2228	2303	2378	2453	2529	2604	8
9	2679	2754	2829	2904	2978	3053	3128	3203	3278	3353	9
580	3428	3503	3578	3653	3727	3802	3877	3952	4027	4101	580
1	4176	4251	4326	4400	4475	4550	4624	4699	4774	4848	1
2	4923	4998	5072	5147	5221	5296	5370	5445	5520	5594	2
3	5669	5743	5818	5892	5966	6041	6115	6190	6264	6338	3
4	6413	6487	6562	6636	6710	6785	6859	6933	7007	7082	4

PROPORTIONAL PARTS.	N.	1	2	3	4	5	6	7	8	9
	5201	8·3	16·6	24 9	33·2	41·5	49·8	58·1	66·4	74·7
	5264	8·2	16·4	24·6	32·8	41·0	49·2	57·4	65·6	73·8
	5328	8·1	16·2	24 3	32·4	40·5	48·6	56·7	64·8	72·9
	5394	8·0	16·0	24 0	32·0	40·0	48·0	56·0	64·0	72·0
	5462	7·9	15·8	23 7	31·6	39·5	47·4	55·3	63·2	71·1
	5532	7·8	15·6	23·4	31·2	39·0	46·8	54·6	62·4	70·2
	5603	7·7	15·4	23 1	30·8	38·5	46·2	53·9	61·6	69·3
	5677	7·6	15·2	22·8	30·4	38·0	45·6	53·2	60·8	68·4
	5752	7·5	15·0	22·5	30·0	37·5	45·0	52·5	60·0	67·5
	5829	7·4	14·8	22·2	29·6	37·0	44·4	51·8	59·2	66·6

No. 585 L. 767.]	LOGARITHMS OF NUMBERS.									[No. 629 L. 799.	
N.	0	1	2	3	4	5	6	7	8	9	N.
585	767156	7230	7304	7379	7453	7527	7601	7675	7749	7823	585
6	7898	7972	8046	8120	8194	8268	8342	8416	8490	8564	6
7	8638	8712	8786	8860	8934	9008	9082	9156	9230	9303	7
8	9377	9451	9525	9599	9673	9746	9820	9894	9968	0042	8
9	770115	0189	0263	0336	0410	0484	0557	0631	0705	0778	9
590	0852	0926	0999	1073	1146	1220	1293	1367	1440	1514	590
1	1587	1661	1734	1808	1881	1955	2028	2102	2175	2248	1
2	2322	2395	2468	2542	2615	2688	2762	2835	2908	2981	2
3	3055	3128	3201	3274	3348	3421	3494	3567	3640	3713	3
4	3786	3860	3933	4006	4079	4152	4225	4298	4371	4444	4
5	4517	4590	4663	4736	4809	4882	4955	5028	5100	5173	5
6	5246	5319	5392	5465	5538	5610	5683	5756	5829	5902	6
7	5974	6047	6120	6193	6265	6338	6411	6483	6556	6629	7
8	6701	6774	6846	6919	6992	7064	7137	7209	7282	7354	8
9	7427	7499	7572	7644	7717	7789	7862	7934	8006	8079	9
600	8151	8224	8296	8368	8441	8513	8585	8658	8730	8802	600
1	8874	8947	9019	9091	9163	9236	9308	9380	9452	9524	1
2	9596	9669	9741	9813	9885	9957	0029	0101	0173	9245	2
3	780317	0389	0461	0533	0605	0677	0749	0821	0893	0965	3
4	1037	1109	1181	1253	1324	1396	1468	1540	1612	1684	4
5	1755	1827	1899	1971	2042	2114	2186	2258	2329	2401	5
6	2473	2544	2616	2688	2759	2831	2902	2974	3046	3117	6
7	3189	3260	3332	3403	3475	3546	3618	3689	3761	3832	7
8	3904	3975	4046	4118	4189	4261	4332	4403	4475	4546	8
9	4617	4689	4760	4831	4902	4974	5045	5116	5187	5259	9
610	5330	5401	5472	5543	5615	5686	5757	5828	5899	5970	610
1	6041	6112	6183	6254	6325	6396	6467	6538	6609	6680	1
2	6751	6822	6893	6964	7035	7106	7177	7248	7319	7390	2
3	7460	7531	7602	7673	7744	7815	7885	7956	8027	8098	3
4	8168	8239	8310	8381	8451	8522	8593	8663	8734	8804	4
5	8875	8946	9016	9087	9157	9228	9299	9369	9440	9510	5
6	9581	9651	9722	9792	9863	9933	0004	0074	0144	0215	6
7	790285	0356	0426	0496	0567	0637	0707	0778	0848	0918	7
8	0988	1059	1129	1199	1269	1340	1410	1480	1550	1620	8
9	1691	1761	1831	1901	1971	2041	2111	2181	2252	2322	9
620	2392	2462	2532	2602	2672	2742	2812	2882	2952	3022	620
1	3092	3162	3231	3301	3371	3441	3511	3581	3651	3721	1
2	3790	3860	3930	4000	4070	4139	4209	4279	4349	4418	2
3	4488	4558	4627	4697	4767	4836	4906	4976	5045	5115	3
4	5185	5254	5324	5393	5463	5532	5602	5672	5741	5811	4
5	5880	5949	6019	6088	6158	6227	6297	6366	6436	6505	5
6	6574	6644	6713	6782	6852	6921	6990	7060	7129	7198	6
7	7268	7337	7406	7475	7545	7614	7683	7752	7821	7890	7
8	7960	8029	8098	8167	8236	8305	8374	8443	8513	8582	8
9	8651	8720	8789	8858	8927	8996	9065	9134	9203	9272	9

PROP. PARTS.	N.	1	2	3	4	5	6	7	8	9
	5908	7·3	14·6	21·9	29·2	36·5	43·8	51·1	58·4	65·7
	5990	7·2	14·4	21·6	28·8	36·0	43·2	50·4	57·6	64·8
	6074	7·1	14·2	21·3	28·4	35·5	42·6	49·7	56·8	63·9
	6160	7·0	14·0	21·0	28·0	35·0	42·0	49·0	56·0	63·0
	6248	6·9	13·8	20·7	27·6	34·5	41·4	48·3	55·2	62·1

No. 630 L. 799.]	LOGARITHMS OF NUMBERS.									[No. 674 L. 829.	
N.	0	1	2	3	4	5	6	7	8	9	N.
630	799341	9409	9478	9547	9616	9685	9754	9823	9892	9961	630
1	800029	0098	0167	0236	0305	0373	0442	0511	0580	0648	1
2	0717	0786	0854	0923	0992	1061	1129	1198	1266	1335	2
3	1404	1472	1541	1609	1678	1747	1815	1884	1952	2021	3
4	2089	2158	2226	2295	2363	2432	2500	2568	2637	2705	4
5	2774	2842	2910	2979	3047	3116	3184	3252	3321	3389	5
6	3457	3525	3594	3662	3730	3798	3867	3935	4003	4071	6
7	4139	4208	4276	4344	4412	4480	4548	4616	4685	4753	7
8	4821	4889	4957	5025	5093	5161	5229	5297	5365	5433	8
9	5501	5569	5637	5705	5773	5841	5908	5976	6044	6112	9
640	806180	6248	6316	6384	6451	6519	6587	6655	6723	6790	640
1	6858	6926	6994	7061	7129	7197	7264	7332	7400	7467	1
2	7535	7603	7670	7738	7806	7873	7941	8008	8076	8143	2
3	8211	8279	8346	8414	8481	8549	8616	8684	8751	8818	3
4	8886	8953	9021	9088	9156	9223	9290	9358	9425	9492	4
5	9560	9627	9694	9762	9829	9896	9964	0031	0098	0165	5
6	810233	0300	0367	0434	0501	0569	0636	0703	0770	0837	6
7	0904	0971	1039	1106	1173	1240	1307	1374	1441	1508	7
8	1575	1642	1709	1776	1843	1910	1977	2044	2111	2178	8
9	2245	2312	2379	2445	2512	2579	2646	2713	2780	2847	9
650	2913	2980	3047	3114	3181	3247	3314	3381	3448	3514	650
1	3581	3648	3714	3781	3848	3914	3981	4048	4114	4181	1
2	4248	4314	4381	4447	4514	4581	4647	4714	4780	4847	2
3	4913	4980	5046	5113	5179	5246	5312	5378	5445	5511	3
4	5578	5644	5711	5777	5843	5910	5976	6042	6109	6175	4
5	6241	6308	6374	6440	6506	6573	6639	6705	6771	6838	5
6	6904	6970	7036	7102	7169	7235	7301	7367	7433	7499	6
7	7565	7631	7698	7764	7830	7896	7962	8028	8094	8160	7
8	8226	8292	8358	8424	8490	8556	8622	8688	8754	8820	8
9	8885	8951	9017	9083	9149	9215	9281	9346	9412	9478	9
660	9544	9610	9676	9741	9807	9873	9939	0004	0070	0136	660
1	820201	0267	0333	0399	0464	0530	0595	0661	0727	0792	1
2	0858	0924	0989	1055	1120	1186	1251	1317	1382	1448	2
3	1514	1579	1645	1710	1775	1841	1906	1972	2037	2103	3
4	2168	2233	2299	2364	2430	2495	2560	2626	2691	2756	4
5	2822	2887	2952	3018	3083	3148	3213	3279	3344	3409	5
6	3474	3539	3605	3670	3735	3800	3865	3930	3996	4061	6
7	4126	4191	4256	4321	4386	4451	4516	4581	4646	4711	7
8	4776	4841	4906	4971	5036	5101	5166	5231	5296	5361	8
9	5426	5491	5556	5621	5686	5751	5815	5880	5945	6010	9
670	6075	6140	6204	6269	6334	6399	6464	6528	6593	6658	670
1	6723	6787	6852	6917	6981	7046	7111	7175	7240	7305	1
2	7369	7434	7499	7563	7628	7692	7757	7821	7886	7951	2
3	8015	8080	8144	8209	8273	8338	8402	8467	8531	8595	3
4	8660	8724	8789	8853	8918	8982	9046	9111	9175	9239	4

PROP. PARTS.	N.	1	2	3	4	5	6	7	8	9
	6340	6·8	13·6	20·4	27·2	34·0	40·8	47·6	54·4	61·2
	6433	6·7	13·4	20·1	26·8	33·5	40·2	46·9	53·6	60·3
	6530	6·6	13·2	19·8	26·4	33·0	39·6	46·2	52·8	59·4
	6630	6·5	13·0	19·5	26·0	32·5	39·0	45·5	52·0	58·5
	6733	6·4	12·8	19·2	25·6	32·0	38·4	44·8	51·2	57·6

No. 675 L. 829.]	LOGARITHMS OF NUMBERS.									[No. 719 L. 857.	
N.	0	1	2	3	4	5	6	7	8	9	N.
675	829304	9368	9432	9497	9561	9625	9690	9754	9818	9882	675
6	9947	0011	0075	0139	0204	0268	0332	0396	0460	0525	6
7	830589	0653	0717	0781	0845	0909	0973	1037	1102	1166	7
8	1230	1294	1358	1422	1486	1550	1614	1678	1742	1806	8
9	1870	1934	1998	2062	2126	2189	2253	2317	2381	2445	9
680	2509	2573	2637	2700	2764	2828	2892	2956	3020	3083	680
1	3147	3211	3275	3338	3402	3466	3530	3593	3657	3721	1
2	3784	3848	3912	3975	4039	4103	4166	4230	4294	4357	2
3	4421	4484	4548	4611	4675	4739	4802	4866	4929	4993	3
4	5056	5120	5183	5247	5310	5373	5437	5500	5564	5627	4
5	5691	5754	5817	5881	5944	6007	6071	6134	6197	6261	5
6	6324	6387	6451	6514	6577	6641	6704	6767	6830	6894	6
7	6957	7020	7083	7146	7210	7273	7336	7399	7462	7525	7
8	7588	7652	7715	7778	7841	7904	7967	8030	8093	8156	8
9	8219	8282	8345	8408	8471	8534	8597	8660	8723	8786	9
690	8849	8912	8975	9038	9101	9164	9227	9289	9352	9415	690
1	9478	9541	9604	9667	9729	9792	9855	9918	9981	0043	1
2	840106	0169	0232	0294	0357	0420	0482	0545	0608	0671	2
3	0733	0796	0859	0921	0984	1046	1109	1172	1234	1297	3
4	1359	1422	1485	1547	1610	1672	1735	1797	1860	1922	4
5	1985	2047	2110	2172	2235	2297	2360	2422	2484	2547	5
6	2609	2672	2734	2796	2859	2921	2983	3046	3108	3170	6
7	3233	3295	3357	3420	3482	3544	3606	3669	3731	3793	7
8	3855	3918	3980	4042	4104	4166	4229	4291	4353	4415	8
9	4477	4539	4601	4664	4726	4788	4850	4912	4974	5036	9
700	5098	5160	5222	5284	5346	5408	5470	5532	5594	5656	700
1	5718	5780	5842	5904	5966	6028	6090	6151	6213	6275	1
2	6337	6399	6461	6523	6585	6646	6708	6770	6832	6894	2
3	6955	7017	7079	7141	7202	7264	7326	7388	7449	7511	3
4	7573	7634	7696	7758	7819	7881	7943	8004	8066	8121	4
5	8189	8251	8312	8374	8435	8497	8559	8620	8682	8743	5
6	8805	8866	8928	8989	9051	9112	9174	9235	9297	9358	6
7	9419	9481	9542	9604	9665	9726	9788	9849	9911	9972	7
8	850033	0095	0156	0217	0279	0340	0401	0462	0524	0585	8
9	0646	0707	0769	0830	0891	0952	1014	1075	1136	1197	9
710	1258	1320	1381	1442	1503	1564	1625	1686	1747	1809	710
1	1870	1931	1992	2053	2114	2175	2236	2297	2358	2419	1
2	2480	2541	2602	2663	2724	2785	2846	2907	2968	3029	2
3	3090	3150	3211	3272	3333	3394	3455	3516	3577	3637	3
4	3698	3759	3820	3881	3941	4002	4063	4124	4185	4245	4
5	4306	4367	4428	4488	4549	4610	4670	4731	4792	4852	5
6	4913	4974	5034	5095	5156	5216	5277	5337	5398	5459	6
7	5519	5580	5640	5701	5761	5822	5882	5943	6003	6064	7
8	6124	6185	6245	6306	6366	6427	6487	6548	6608	6668	8
9	6729	6789	6850	6910	6970	7031	7091	7152	7212	7272	9

PROP. PARTS.	N.	1	2	3	4	5	6	7	8	9
	6839	6·3	12·6	18·9	25·2	31·5	37·8	44·1	50·4	56·7
	6948	6·2	12·4	18·6	24·8	31·0	37·2	43·4	49·6	55·8
	7061	6·1	12·2	18·3	24·4	30·5	36·6	42·7	48·8	54·9
	7178	6·0	12·0	18·0	24·0	30·0	36·0	42·0	48·0	54·0

No. 720 L. 857.] LOGARITHMS OF NUMBERS. [No. 764 L. 883.

N.	0	1	2	3	4	5	6	7	8	9	N.
720	857332	7393	7453	7513	7574	7634	7694	7755	7815	7875	720
1	7935	7995	8056	8116	8176	8236	8297	8357	8417	8477	1
2	8537	8597	8657	8718	8778	8838	8898	8958	9018	9078	2
3	9138	9198	9258	9318	9379	9439	9499	9559	9619	9679	3
4	9739	9799	9859	9918	9978	0038	0098	0158	0218	0278	4
5	860338	0398	0458	0518	0578	0637	0697	0757	0817	0877	5
6	0937	1996	1056	1116	1176	1231	1295	1355	1415	1475	6
7	1534	1594	1654	1714	1773	1833	1893	1952	2012	2072	7
8	2131	2191	2251	2310	2370	2430	2489	2543	2608	2668	8
9	2728	2787	2847	2906	2966	3025	3085	3144	3204	3263	9
730	3323	3382	3442	3501	3561	3620	3680	3739	3799	3858	730
1	3917	3977	4036	4096	4155	4214	4274	4333	4392	4452	1
2	4511	4570	4630	4689	4748	4808	4867	4926	4985	5045	2
3	5104	5163	5222	5282	5341	5400	5459	5519	5578	5637	3
4	5696	5755	5814	5874	5933	5992	6051	6110	6169	6228	4
5	6287	6346	6405	6465	6524	6583	6642	6701	6760	6819	5
6	6878	6937	6996	7055	7114	7173	7232	7291	7350	7409	6
7	7467	7526	7585	7644	7703	7762	7821	7880	7939	7998	7
8	8056	8115	8174	8233	8292	8350	8409	8468	8527	8586	8
9	8644	8703	8762	8821	8879	8938	8997	9056	9114	9173	9
740	9232	9290	9349	9408	9466	9525	9584	9642	9701	9760	740
1	9818	9877	9935	9994	0053	0111	0170	0228	0287	0345	1
2	870404	0462	0521	0579	0638	0696	0755	0813	0872	0930	2
3	0989	1047	1106	1164	1223	1281	1339	1398	1456	1515	3
4	1573	1631	1690	1748	1806	1865	1923	1981	2040	2098	4
5	2156	2215	2273	2331	2389	2448	2506	2564	2622	2681	5
6	2739	2797	2855	2913	2972	3030	3088	3146	3204	3262	6
7	3321	3379	3437	3495	3553	3611	3669	3727	3785	3844	7
8	3902	3960	4018	4076	4134	4192	4250	4308	4366	4424	8
9	4482	4540	4598	4656	4714	4772	4830	4888	4945	5003	9
750	5061	5119	5177	5235	5293	5351	5409	5466	5524	5582	750
1	5640	5698	5756	5813	5871	5929	5987	6045	6102	6160	1
2	6218	6276	6333	6391	6449	6507	6564	6622	6680	6737	2
3	6795	6853	6910	6968	7026	7083	7141	7199	7256	7314	3
4	7371	7429	7487	7544	7602	7659	7717	7774	7832	7889	4
5	7947	8004	8062	8119	8177	8234	8292	8349	8407	8464	5
6	8522	8579	8637	8694	8752	8809	8866	8924	8981	9039	6
7	9096	9153	9211	9268	9325	9383	9440	9497	9555	9612	7
8	9669	9726	9784	9841	9898	9956	0013	0070	0127	0185	8
9	880242	0299	0356	0413	0471	0528	0585	0642	0699	0756	9
760	0814	0871	0928	0985	1042	1099	1156	1213	1271	1328	760
1	1385	1442	1499	1556	1613	1670	1727	1784	1841	1898	1
2	1955	2012	2069	2126	2183	2240	2297	2354	2411	2468	2
3	2525	2581	2638	2695	2752	2809	2866	2923	2980	3037	3
4	3093	3150	3207	3264	3321	3377	3434	3491	3548	3605	4

PROP. PARTS.	N.	1	2	3	4	5	6	7	8	9
	7299	5·9	11·8	17·7	23·6	29·5	35·4	41·3	47·2	53·1
	7423	5·8	11·6	17·4	23·2	29·0	34·8	40·6	46·4	52·2
	7552	5·7	11·4	17·1	22·8	28·5	34·2	39·9	45·6	51·3

No. 765 L. 883.]	LOGARITHMS OF NUMBERS.									[No. 809 L. 908.	
N.	0	1	2	3	4	5	6	7	8	9	N.
765	883661	3718	3775	3832	3888	3945	4002	4059	4115	4172	765
6	4229	4285	4342	4399	4455	4512	4569	4625	4682	4739	6
7	4795	4852	4909	4965	5022	5078	5135	5192	5248	5305	7
8	5361	5418	5474	5531	5587	5644	5700	5757	5813	5870	8
9	5926	5983	6039	6096	6152	6209	6265	6321	6378	6434	9
770	6491	6547	6604	6660	6716	6773	6829	6885	6942	6998	770
1	7054	7111	7167	7223	7280	7336	7392	7449	7505	7561	1
2	7617	7674	7730	7786	7842	7898	7955	8011	8067	8123	2
3	8179	8236	8292	8348	8404	8460	8516	8573	8629	8685	3
4	8741	8797	8853	8909	8965	9021	9077	9134	9190	9246	4
5	9302	9358	9414	9470	9526	9582	9638	9694	9750	9806	5
6	9862	9918	9974	0030	0086	0141	0197	0253	0309	0365	6
7	890421	0477	0533	0589	0645	0700	0756	0812	0868	0924	7
8	0980	1035	1091	1147	1203	1259	1314	1370	1426	1482	8
9	1537	1593	1649	1705	1760	1816	1872	1928	1983	2039	9
780	2095	2150	2206	2262	2317	2373	2429	2484	2540	2595	780
1	2651	2707	2762	2818	2873	2929	2985	3040	3096	3151	1
2	3207	3262	3318	3373	3429	3484	3540	3595	3651	3706	2
3	3762	3817	3873	3928	3984	4039	4094	4150	4205	4261	3
4	4316	4371	4427	4482	4538	4593	4648	4704	4759	4814	4
5	4870	4925	4980	5036	5091	5146	5201	5257	5312	5367	5
6	5423	5478	5533	5588	5644	5699	5754	5809	5864	5920	6
7	5975	6030	6085	6140	6195	6251	6306	6361	6416	6471	7
8	6526	6581	6636	6692	6747	6802	6857	6912	6967	7022	8
9	7077	7132	7187	7242	7297	7352	7407	7462	7517	7572	9
790	7627	7682	7737	7792	7847	7902	7957	8012	8067	8122	790
1	8176	8231	8286	8341	8396	8451	8506	8561	8615	8670	1
2	8725	8780	8835	8890	8944	8999	9054	9109	9164	9218	2
3	9273	9328	9383	9437	9492	9547	9602	9656	9711	9766	3
4	9821	9875	9930	9985	0039	0094	0149	0203	0258	0312	4
5	900367	0422	0476	0531	0586	0640	0695	0749	0804	0859	5
6	0913	0968	1022	1077	1131	1186	1240	1295	1349	1404	6
7	1458	1513	1567	1622	1676	1731	1785	1840	1894	1948	7
8	2003	2057	2112	2166	2221	2275	2329	2384	2438	2492	8
9	2547	2601	2655	2710	2764	2818	2873	2927	2981	3036	9
800	3090	3144	3199	3253	3307	3361	3416	3470	3524	3578	800
1	3633	3687	3741	3795	3849	3904	3958	4012	4066	4120	1
2	4174	4229	4283	4337	4391	4445	4499	4553	4607	4661	2
3	4716	4770	4824	4878	4932	4986	5040	5094	5148	5202	3
4	5256	5310	5364	5418	5472	5526	5580	5634	5688	5742	4
5	5796	5850	5904	5958	6012	6066	6119	6173	6227	6281	5
6	6335	6389	6443	6497	6551	6604	6658	6712	6766	6820	6
7	6874	6927	6981	7035	7089	7143	7196	7250	7304	7358	7
8	7411	7465	7519	7573	7626	7680	7734	7787	7841	7895	8
9	7949	8002	8056	8109	8163	8217	8270	8324	8378	8431	9

PROP. PARTS.	N.	1	2	3	4	5	6	7	8	9
	7686	5·6	11·2	16·8	22·4	28·0	33·6	39·2	44·8	50·4
	7825	5·5	11·0	16·5	22·0	27·5	33·0	38·5	44·0	49·5
	7968	5·4	10·8	16·2	21·6	27·0	32·4	37·8	43·2	48·6

No. 810 L. 908.] LOGARITHMS OF NUMBERS. [No. 854 L. 931.

N.	0	1	2	3	4	5	6	7	8	9	N.
810	908485	8539	8592	8646	8699	8753	8807	8860	8914	8967	810
1	9021	9074	9128	9181	9235	9289	9342	9396	9449	9503	1
2	9556	9609	9663	9716	9770	9823	9877	9930	6984	0037	2
3	910091	0144	0197	0251	0304	0358	0411	0464	0518	0571	3
4	0624	0678	0731	0784	0838	0891	0944	0998	1051	1104	4
5	1158	1211	1264	1317	1371	1424	1477	1530	1584	1637	5
6	1690	1743	1797	1850	1903	1956	2009	2063	2116	2169	6
7	2222	2275	2328	2381	2435	2488	2541	2594	2647	2700	7
8	2753	2806	2859	2913	2966	3019	3072	3125	3178	3231	8
9	3284	3337	3390	3443	3496	3549	3602	3655	3708	3761	9
820	3814	3867	3920	3973	4026	4079	4132	4184	4237	4290	820
1	4343	4396	4449	4502	4555	4608	4660	4713	4766	4819	1
2	4872	4925	4977	5030	5083	5136	5189	5241	5294	5347	2
3	5400	5453	5505	5558	5611	5664	5716	5769	5822	5875	3
4	5927	5980	6033	6085	6138	6191	6243	6296	6349	6401	4
5	6454	6507	6559	6612	6664	6717	6770	6822	6875	6927	5
6	6980	7033	7085	7138	7190	7243	7295	7348	7400	7453	6
7	7506	7558	7611	7663	7716	7768	7820	7873	7925	7978	7
8	8030	8083	8135	8188	8240	8293	8345	8397	8450	8502	8
9	8555	8607	8659	8712	8764	8816	8869	8921	8973	9026	9
830	9078	9130	9183	9235	9287	9340	9392	9444	9496	9549	830
1	9601	9653	9706	9758	9810	9862	9914	9967	0019	0071	1
2	920123	0176	0228	0280	0332	0384	0436	0489	0541	0593	2
3	0645	0697	0749	0801	0853	0906	0958	1010	1062	1114	3
4	1166	1218	1270	1322	1374	1426	1478	1530	1582	1634	4
5	1686	1738	1790	1842	1894	1946	1998	2050	2102	2154	5
6	2206	2258	2310	2362	2414	2466	2518	2570	2622	2674	6
7	2725	2777	2829	2881	2933	2985	3037	3089	3140	3192	7
8	3244	3296	3348	3399	3451	3503	3555	3607	3658	3710	8
9	3762	3814	3865	3917	3969	4021	4072	4124	4176	4228	9
840	4279	4331	4383	4434	4486	4538	4589	4641	4693	4744	840
1	4796	4848	4899	4951	5003	5054	5106	5157	5209	5261	1
2	5312	5364	5415	5467	5518	5570	5621	5673	5725	5776	2
3	5828	5879	5931	5982	6034	6085	6137	6188	6239	6291	3
4	6342	6394	6445	6497	6548	6600	6651	6702	6754	6805	4
5	6857	6908	6959	7011	7062	7114	7165	7216	7268	7319	5
6	7370	7422	7473	7524	7576	7627	7678	7730	7781	7832	6
7	7883	7935	7986	8037	8088	8140	8191	8242	8293	8345	7
8	8396	8447	8498	8549	8601	8652	8703	8754	8805	8857	8
9	8908	8959	9010	9061	9112	9163	9215	9266	9317	9368	9
850	9419	9470	9521	9572	9623	9674	9725	9776	9827	9879	850
1	9930	9981	0032	0083	0134	0185	0236	0287	0338	0389	1
2	930440	0491	0542	0592	0643	0694	0745	0796	0847	0898	2
3	0949	1000	1051	1102	1153	1203	1254	1305	1356	1407	3
4	1458	1509	1560	1610	1661	1712	1763	1814	1864	1915	4

PROP. PARTS.	N.	1	2	3	4	5	6	7	8	9
	8117	5·3	10·6	15·9	21·2	26·5	31·8	37·1	42·4	47·7
	8271	5·2	10·4	15·6	20·8	26·0	31·2	36·4	41·6	46·8
	8432	5·1	10·2	15·3	20·4	25·5	30·6	35·7	40·8	45·9

No. 855 L. 931.]	LOGARITHMS OF NUMBERS.									[No. 899 L. 954	
N.	0	1	2	3	4	5	6	7	8	9	N.
855	931966	2017	2068	2118	2169	2220	2271	2322	2372	2423	855
6	2474	2524	2575	2626	2677	2727	2778	2829	2879	2930	6
7	2981	3031	3082	3133	3183	3234	3285	3335	3386	3437	7
8	3487	3538	3589	3639	3690	3740	3791	3841	3892	3943	8
9	3993	4044	4094	4145	4195	4246	4296	4347	4397	4448	9
860	4498	4549	4599	4650	4700	4751	4801	4852	4902	4953	860
1	5003	5054	5104	5154	5205	5255	5306	5356	5406	5457	1
2	5507	5558	5608	5658	5709	5759	5809	5860	5910	5960	2
3	6011	6061	6111	6162	6212	6262	6313	6363	6413	6463	3
4	6514	6564	6614	6665	6715	6765	6815	6865	6916	6966	4
5	7016	7066	7116	7167	7217	7267	7317	7367	7418	7468	5
6	7518	7568	7618	7668	7718	7769	7819	7869	7919	7969	6
7	8019	8069	8119	8169	8219	8269	8319	8370	8420	8470	7
8	8520	8570	8620	8670	8720	8770	8820	8870	8920	8970	8
9	9020	9070	9120	9170	9220	9270	9319	9369	9419	9469	9
870	9519	9569	9619	9669	9719	9769	9819	9869	9918	9968	870
1	940018	0068	0118	0168	0218	0267	0317	0367	0417	0467	1
2	0516	0566	0616	0666	0716	0765	0815	0865	0915	0964	2
3	1014	1064	1114	1163	1213	1263	1313	1362	1412	1462	3
4	1511	1561	1611	1660	1710	1760	1809	1859	1909	1958	4
5	2008	2058	2107	2157	2207	2256	2306	2355	2405	2455	5
6	2504	2554	2603	2653	2702	2752	2801	2851	2901	2950	6
7	3000	3049	3099	3148	3198	3247	3297	3346	3396	3445	7
8	3495	3544	3593	3643	3692	3742	3791	3841	3890	3939	8
9	3989	4038	4088	4137	4186	4236	4285	4335	4384	4433	9
880	4483	4532	4581	4631	4680	4729	4779	4828	4877	4927	880
1	4976	5025	5074	5124	5173	5222	5272	5321	5370	5419	1
2	5469	5518	5567	5616	5665	5715	5764	5813	5862	5912	2
3	5961	6010	6059	6108	6157	6207	6256	6305	6354	6403	3
4	6452	6501	6551	6600	6649	6698	6747	6796	6845	6894	4
5	6943	6992	7041	7090	7139	7189	7238	7287	7336	7385	5
6	7434	7483	7532	7581	7630	7679	7728	7777	7826	7875	6
7	7924	7973	8022	8070	8119	8168	8217	8266	8315	8364	7
8	8413	8462	8511	8560	8608	8657	8706	8755	8804	8853	8
9	8902	8951	8999	9048	9097	9146	9195	9244	9292	9341	9
890	9390	9439	9488	9536	9585	9634	9683	9731	9780	9829	890
1	9878	9926	9975	0024	0073	0121	0170	0219	0267	0316	1
2	950365	0414	0462	0511	0560	0608	0657	0706	0754	0803	2
3	0851	0900	0949	0997	1046	1095	1143	1192	1240	1289	3
4	1338	1386	1435	1483	1532	1580	1629	1677	1726	1775	4
5	1823	1872	1920	1969	2017	2066	2114	2163	2211	2259	5
6	2308	2356	2405	2453	2502	2550	2599	2647	2696	2744	6
7	2792	2841	2889	2938	2986	3034	3083	3131	3180	3228	7
8	3276	3325	3373	3421	3470	3518	3566	3615	3663	3711	8
9	3760	3808	3856	3905	3953	4001	4049	4098	4146	4194	9

PROP. PARTS.	N.	1	2	3	4	5	6	7	8	9
	8599	5·0	10·0	15·0	20·0	25·0	30·0	35·0	40·0	45·0
	8773	4·9	9·8	14·7	19·6	24·5	29·4	34·3	39·2	44·1
	8954	4·8	9·6	14·4	19·2	24·0	28·8	33·6	38·4	43·2

No. 900 L. 954.]	LOGARITHMS OF NUMBERS.									[No. 944 L. 975.	
N.	0	1	2	3	4	5	6	7	8	9	N.
900	954243	4291	4339	4387	4435	4484	4532	4580	4628	4677	900
1	4725	4773	4821	4869	4918	4966	5014	5062	5110	5158	1
2	5207	5255	5303	5352	5399	5447	5495	5543	5592	5640	2
3	5688	5736	5784	5832	5880	5928	5976	6024	6072	6120	3
4	6168	6216	6265	6313	6361	6409	6457	6505	6553	6601	4
5	6649	6697	6745	6793	6840	6888	6936	6984	7032	7080	5
6	7128	7176	7224	7272	7320	7368	7416	7464	7512	7559	6
7	7607	7655	7703	7751	7799	7847	7894	7942	7990	8038	7
8	8086	8134	8181	8229	8277	8325	8373	8421	8468	8516	8
9	8564	8612	8659	8707	8755	8803	8850	8898	8946	8994	9
910	9041	9089	9137	9185	9232	9280	9328	9375	9423	9471	910
1	9518	9566	9614	9661	9709	9757	9804	9852	9900	9947	1
2	9995	0042	0090	0138	0185	0233	0281	0328	0376	0423	2
3	960471	0518	0566	0613	0661	0709	0756	0804	0851	0899	3
4	0946	0994	1041	1089	1136	1184	1231	1279	1326	1374	4
5	1421	1469	1516	1563	1611	1658	1706	1753	1801	1848	5
6	1895	1943	1990	2038	2085	2132	2180	2227	2275	2322	6
7	2369	2417	2464	2511	2559	2606	2653	2701	2748	2795	7
8	2843	2890	2937	2985	3032	3079	3126	3174	3221	3268	8
9	3316	3363	3410	3457	3504	3552	3599	3646	3693	3741	9
920	3788	3835	3882	3929	3977	4024	4071	4118	4165	4212	920
1	4260	4307	4354	4401	4448	4495	4542	4590	4637	4684	1
2	4731	4778	4825	4872	4919	4966	5013	5060	5108	5155	2
3	5202	5249	5296	5343	5390	5437	5484	5531	5578	5625	3
4	5672	5719	5766	5813	5860	5907	5954	6001	6048	6095	4
5	6142	6189	6236	6283	6329	6376	6423	6470	6517	6564	5
6	6611	6658	6705	6752	6799	6845	6892	6939	6986	7033	6
7	7080	7127	7173	7220	7267	7314	7361	7408	7454	7501	7
8	7548	7595	7642	7688	7735	7782	7829	7875	7922	7969	8
9	8016	8062	8109	8156	8203	8249	8296	8343	8389	8436	9
930	8483	8530	8576	8623	8670	8716	8763	8810	8856	8903	930
1	8950	8996	9043	9090	9136	9183	9229	9276	9323	9369	1
2	9416	9463	9509	9556	9602	9649	9695	9742	9789	9835	2
3	9882	9928	9975	0021	0068	0114	0161	0207	0254	0300	3
4	970347	0393	0440	0486	0533	0579	0626	0672	0719	0765	4
5	0812	0858	0904	0951	0997	1044	1090	1137	1183	1229	5
6	1276	1322	1369	1415	1461	1508	1554	1601	1647	1693	6
7	1740	1786	1832	1879	1925	1971	2018	2064	2110	2157	7
8	2203	2249	2295	2342	2388	2434	2481	2527	2573	2619	8
9	2666	2712	2758	2804	2851	2897	2943	2989	3035	3082	9
940	3128	3174	3220	3266	3313	3359	3405	3451	3497	3543	940
1	3590	3636	3682	3728	3774	3820	3866	3913	3959	4005	1
2	4051	4079	4143	4189	4235	4281	4327	4374	4420	4466	2
3	4512	4558	4604	4650	4696	4742	4788	4834	4880	4926	3
4	4972	5018	5064	5110	5156	5202	5248	5294	5340	5386	4

PROP. PARTS.	N.	1	2	3	4	5	6	7	8	9
	9143	4·7	9·4	14·1	18·8	23·5	28·2	32·9	37·6	42·3
	9339	4·6	9·2	13·8	18·4	23·0	27·6	32·2	36·8	41·4
	9544	4·5	9·0	13·5	18·0	22·5	27·0	31·5	36·0	40·5

No. 945 L. 975.]	LOGARITHMS OF NUMBERS.									[No. 989 L. 995.	
N.	0	1	2	3	4	5	6	7	8	9	N.
945	975432	5478	5524	5570	5616	5662	5707	5753	5799	5845	945
6	5891	5937	5983	6029	6075	6121	6167	6212	6258	6304	6
7	6350	6396	6442	6488	6533	6579	6625	6671	6717	6763	7
8	6808	6854	6900	6946	6992	7037	7083	7129	7175	7220	8
9	7266	7312	7358	7403	7449	7495	7541	7586	7632	7678	9
950	7724	7769	7815	7861	7906	7952	7998	8043	8089	8135	950
1	8181	8226	8272	8317	8363	8409	8454	8500	8546	8591	1
2	8637	8683	8728	8774	8819	8865	8911	8956	9002	9047	2
3	9093	9138	9184	9230	9275	9321	9366	9412	9457	9503	3
4	9548	9594	9639	9685	9730	9776	9821	9867	9912	9958	4
5	980003	0049	0094	0140	0185	0231	0276	0322	0367	0412	5
6	0458	0503	0549	0594	0640	0685	0730	0776	0821	0867	6
7	0912	0957	1003	1048	1093	1139	1184	1229	1275	1320	7
8	1366	1411	1456	1501	1547	1592	1637	1683	1728	1773	8
9	1819	1864	1909	1954	2000	2045	2090	2135	2181	2226	9
960	2271	2316	2362	2407	2452	2497	2543	2588	2633	2678	960
1	2723	2769	2814	2859	2904	2949	2994	3040	3085	3130	1
2	3175	3220	3265	3310	3356	3401	3446	3491	3536	3581	2
3	3626	3671	3716	3762	3807	3852	3897	3942	3987	4032	3
4	4077	4122	4167	4212	4257	4302	4347	4392	4437	4482	4
5	4527	4572	4617	4662	4707	4752	4797	4842	4887	4932	5
6	4977	5022	5067	5112	5157	5202	5247	5292	5337	5382	6
7	5426	5471	5516	5561	5606	5651	5696	5741	5786	5830	7
8	5875	5920	5965	6010	6055	6100	6144	6189	6234	6279	8
9	6324	6369	6413	6458	6503	6548	6593	6637	6682	6727	9
970	6772	6817	6861	6906	6951	6996	7040	7085	7130	7175	970
1	7219	7264	7309	7353	7398	7443	7488	7532	7577	7622	1
2	7666	7711	7756	7800	7845	7890	7934	7979	8024	8068	2
3	8113	8157	8202	8247	8291	8336	8381	8425	8470	8514	4
4	8559	8604	8648	8693	8737	8782	8826	8871	8916	8960	4
5	9005	9049	9094	9138	9183	9227	9272	9316	9361	9405	5
6	9450	9494	9539	9583	9628	9672	9717	9761	9806	9850	6
7	9895	9939	9983	0028	0072	0117	0161	0206	0250	0294	7
8	990339	0383	0428	0472	0516	0561	0605	0650	0694	0738	8
9	0783	0827	0871	0916	0960	1004	1049	1093	1137	1182	9
980	1226	1270	1315	1359	1403	1448	1492	1536	1580	1625	980
1	1669	1713	1758	1802	1846	1890	1935	1979	2023	2067	1
2	2111	2156	2200	2244	2288	2333	2377	2421	2465	2509	2
3	2554	2598	2642	2686	2730	2774	2819	2863	2907	2951	3
4	2995	3039	3083	3127	3172	3216	3260	3304	3348	3392	4
5	3436	3480	3524	3568	3613	3657	3701	3745	3789	3833	5
6	3877	3921	3965	4009	4053	4097	4141	4185	4229	4273	6
7	4317	4361	4405	4449	4493	4537	4581	4625	4669	4713	7
8	4757	4801	4845	4889	4933	4977	5021	5065	5108	5152	8
9	5196	5240	5284	5328	5372	5416	5460	5504	5547	5591	9

PROP. PARTS.	N.	1	2	3	4	5	6	7	8	9
	9759	4·4	8·8	13·2	17·6	22·0	26·4	30·8	35·2	39·6
	9983	4·3	8·6	12·9	17·2	21·5	25·8	30·1	34·4	38·7

No. 990 L. 995.]				LOGARITHMS OF NUMBERS.						[No. 999 L. 999.	
N.	0	1	2	3	4	5	6	7	8	9	N.
990	995635	5679	5723	5767	5811	5854	5898	5942	5986	6030	990
1	6074	6117	6161	6205	6249	6293	6337	6380	6424	6468	1
2	6512	6555	6599	6643	6687	6731	6774	6818	6862	6906	2
3	6949	6993	7037	7080	7124	7168	7212	7255	7299	7343	3
4	7386	7430	7474	7517	7561	7605	7648	7692	7736	7779	4
5	7823	7867	7910	7954	7998	8041	8085	8129	8172	8216	5
6	8259	8303	8347	8390	8434	8477	8521	8564	8608	8652	6
7	8695	8739	8782	8826	8869	8913	8956	9000	9043	9087	7
8	9130	9174	9218	9261	9305	9348	9392	9435	9479	9522	8
9	9565	9609	9652	9696	9739	9783	9826	9870	9913	9957	9

TABLE II.—LOGARITHMS OF NUMBERS FROM 1 TO 100.

N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.
1	0·000000	21	1·322219	41	1·612784	61	1·785330	81	1·908485
2	0·301030	22	1·342423	42	1·623249	62	1·792392	82	1·913814
3	0·477121	23	1·361728	43	1·633468	63	1·799341	83	1·919078
4	0·602060	24	1·380211	44	1·643453	64	1·806180	84	1·924279
5	0·698970	25	1·397940	45	1·653213	65	1·812913	85	1·929419
6	0·778151	26	1·414973	46	1·662758	66	1·819544	86	1·934498
7	0·845098	27	1·431364	47	1·672098	67	1·826075	87	1·939519
8	0·903090	28	1·447158	48	1·681241	68	1·832509	88	1·944483
9	0·954243	29	1·462398	49	1·690196	69	1·838849	89	1·949390
10	1·000000	30	1·477121	50	1·698970	70	1·845098	90	1·954243
11	1·041393	31	1·491362	51	1·707570	71	1·851258	91	1·959041
12	1·079181	32	1·505150	52	1·716003	72	1·857332	92	1·963788
13	1·113943	33	1·518514	53	1·724276	73	1·863323	93	1·968483
14	1·146128	34	1·531479	54	1·732394	74	1·869232	94	1·973128
15	1·176091	35	1·544068	55	1·740363	75	1·875061	95	1·977724
16	1·204120	36	1·556302	56	1·748188	76	1·880814	96	1·982271
17	1·230449	37	1·568202	57	1·755875	77	1·886491	97	1·986772
18	1·255273	38	1·579784	58	1·763428	78	1·892095	98	1·991226
19	1·278754	39	1·591065	59	1·770852	79	1·897627	99	1·995635
20	1·301030	40	1·602060	60	1·778151	80	1·903090	100	2·000000

TABLE III.

	Value at 0°.	Sign in 1st Quad.	Value at 90°.	Sign in 2nd Quad.	Value at 180°.	Sign in 3rd Quad.	Value at 270°.	Sign in 4th Quad.	Value at 360°.
Sin	0	+	R	+	0	−	R	−	0
Tan....	0	+	∞	−	0	+	∞	−	0
Sec	R	+	∞	−	R	−	∞	+	R
Versin	0	+	R	+	2 R	+	R	+	0
Cos	R	+	0	−	R	−	0	+	R
Cot.....	∞	+	0	−	∞	+	0	−	∞
Cosec..	∞	+	R	+	∞	−	R	−	∞

R signifies equal to rad; ∞ signifies infinite; 0 signifies evanescent.

TABLE IV.—Logarithmic Sines.

		·0	·1	·2	·3	·4	·5		
°	′								
0	0		5·463726	5·764756	5·940847	6·065786	6·162696	89	59
	1	6·463726	6·505119	6·542907	6·577669	609854	639817		58
	2	764756	785945	806149	825454	843937	861666		57
	3	940847	955088	968876	982240	995205	7·007794		56
	4	7·065786	7·076510	7·086975	7·097194	7·107179	116938		55
	5	162696	171296	179729	188002	196120	204089		54
	6	241877	249056	256118	263066	269906	276639		53
	7	308824	314984	321058	327049	332958	338787		52
	8	366816	372211	377540	382804	388005	393145	89	51
0	9	7·417968	7·422767	7·427513	7·432208	7·436853	7·441449		50
	10	463725	468047	472326	476563	480759	484915		49
	11	505118	509048	512943	516804	520630	524423		48
	12	542906	546511	550085	553630	557147	560635		47
	13	577668	580996	584299	587577	590830	594059		46
	14	609853	612944	616013	619061	622087	625093		45
	15	639816	642702	645568	648416	651245	654056		44
	16	667845	670550	673239	675912	678568	681208		43
	17	694173	696720	699253	701770	704273	706762	89	42
0	18	7·718997	7·721403	7·723795	7·726175	7·728542	7·730896		41
	19	742477	744757	747025	749281	751525	753758		40
	20	764754	766920	769075	771220	773354	775477		39
	21	785943	788006	790059	792103	794137	796162		38
	22	806146	808115	810076	812028	813971	815905		37
	23	825451	827335	829211	831079	832939	834791		36
	24	843934	845740	847538	849329	851112	852888		35
	25	861662	863396	865123	866843	868556	870262		34
	26	878695	880362	882023	883678	885326	886968	89	33
0	27	7·895085	7·896691	7·898291	7·899884	7·901472	7·903054		32
	28	910879	912428	913970	915508	917039	918566		31
	29	926119	927614	929104	930589	932068	933543		30
	30	940842	942287	943727	945163	946594	948020		29
	31	955082	956481	957875	959264	960650	962031		28
	32	968870	970225	971576	972922	974265	975603		27
	33	982233	983547	984857	986164	987466	988764		26
	34	995198	996473	997745	999013	8·000277	8·001538		25
	35	8·007787	8·009026	8·010261	8·011493	012722	013947	89	24
0	36	8·020021	8·021225	8·022427	8·023625	8·024819	8·026011		23
	37	031919	033092	034261	035426	036589	037749		22
	38	043501	044642	045781	046916	048048	049178		21
	39	054781	055893	057003	058109	059213	060314		20
	40	065776	066861	067942	069021	070098	071171		19
	41	076500	077558	078613	079666	080716	081764		18
	42	086965	087997	089028	090056	091081	092104		17
	43	097183	098192	099198	100203	101204	102204		16
	44	107167	108153	109136	110118	111097	112074		15
	45	116926	117890	118852	119812	120769	121725	89	14
								°	′
		1·0	·9	·8	·7	·6	·5		

Log. Cosines.

Table IV.—Logarithmic Sines.

		·6	·7	·8	·9	1·0		
°	′							
0	0	6·241877	6·308824	6·366816	6·417969	6·463726	89	59
	1	667846	694175	718999	742480	764756		58
	2	878699	895090	910884	926124	940847		57
	3	7·020028	7·031928	7·043510	7·054791	7·065786		56
	4	126484	135824	144967	153922	162696		55
	5	211914	219601	227154	234578	241877		54
	6	283270	289801	296235	302575	308824		53
	7	344539	350217	355820	361353	366816		52
	8	398224	403245	408208	413116	417968	89	51
0	9	7·445998	7·450497	7·454952	7·459361	7·463725		50
	10	489031	493109	497149	501152	505118		49
	11	528183	531911	535607	539272	542906		48
	12	564096	567529	570935	574315	577668		47
	13	597264	600445	603604	606740	609853		46
	14	628078	631042	633986	636911	639816		45
	15	656849	659624	662382	665122	667844		44
	16	683832	686441	689034	691611	694173		43
	17	709237	711697	714144	716577	718997	89	42
0	18	7·733237	7·735566	7·737882	7·740186	7·742477		41
	19	755980	758190	760389	762577	764754		40
	20	777591	779694	781787	783870	785943		39
	21	798177	800183	802180	804167	806146		38
	22	817831	819749	821658	823558	825451		37
	23	836635	838471	840300	842120	843934		36
	24	854657	856419	858174	859922	861662		35
	25	871962	873655	875342	877022	878695		34
	26	888603	890233	891856	893474	895085	89	33
0	27	7·904630	7·906201	7·907766	7·909326	7·910879		32
	28	920087	921603	923113	924619	926119		31
	29	935012	936477	937937	939392	940842		30
	30	949442	950859	952271	953679	955082		29
	31	963407	964779	966147	967511	968870		28
	32	976937	978267	979593	980915	982233		27
	33	990058	991349	992636	993919	995198		26
	34	8·002795	8·004048	8·005298	8·006544	8·007787		25
	35	015168	016386	017601	018813	020021	89	24
0	36	8·027199	8·028384	8·029566	8·030744	8·031919		23
	37	038905	040059	041209	042356	043501		22
	38	050304	051428	052549	053666	054781		21
	39	061412	062507	063599	064689	065776		20
	40	072242	073310	074376	075439	076500		19
	41	082809	083851	084892	085929	086965		18
	42	093125	094143	095159	096172	097183		17
	43	103201	104196	105188	106179	107167		16
	44	113049	114021	114992	115960	116926		15
	45	122678	123629	124579	125526	126471	89	14
							°	′
		·4	·3	·2	·1	·0		

Log. Cosines.

TABLE IV.—Logarithmic Sines.

		·0	·1	·2	·3	·4	·5		
°	′								
0	45	8·116926	8·117890	8·118852	8·119812	8·120769	8·121725	89	14
	46	126471	127414	128355	129294	130231	131166		13
	47	135810	136733	137654	138574	139491	140406		12
	48	144953	145857	146759	147659	148557	149453		11
	49	153907	154793	155676	156558	157438	158316		10
	50	162681	163548	164414	165279	166141	167002		9
	51	171280	172131	172980	173827	174673	175517		8
	52	179713	180547	181380	182211	183041	183868		7
	53	187985	188803	189620	190436	191250	192062	89	6
0	54	8·196102	8·196905	8·197707	8·198508	8·199307	8·200104		5
	55	204070	204859	205646	206432	207217	208000		4
	56	211895	212670	213443	214215	214986	215755		3
	57	219581	220342	221102	221861	222618	223374		2
	58	227134	227882	228628	229374	230118	230861		1
	59	234557	235292	236026	236759	237491	238221	89	0
1	0	241855	242578	243300	244021	244741	245459		59
	1	249033	249744	250455	251164	251871	252578		58
	2	256094	256794	257492	258190	258887	259582	89	57
1	3	8·263042	8·263731	8·264419	8·265105	8·265791	8·266475		56
	4	269881	270559	271236	271912	272587	273260		55
	5	276614	277281	277948	278613	279278	279941		54
	6	283243	283901	284557	285213	285867	286521		53
	7	289773	290421	291068	291713	292358	293002		52
	8	296207	296845	297482	298118	298754	299388		51
	9	302546	303174	303803	304430	305056	305681		50
	10	308794	309414	310033	310651	311268	311885		49
	11	314954	315565	316175	316784	317393	318001	89	48
1	12	8·321027	8·321629	8·322231	8·322832	8·323433	8·324032		47
	13	327016	327611	328204	328797	329389	329980		46
	14	332924	333511	334096	334681	335265	335848		45
	15	338753	339331	339909	340486	341063	341638		44
	16	344504	345075	345645	346215	346784	347352		43
	17	350181	350744	351307	351869	352430	352991		42
	18	355783	356340	356895	357450	358004	358558		41
	19	361315	361864	362413	362961	363508	364054		40
	20	366777	367319	367861	368402	368943	369482	88	39
1	21	8·372171	8·372707	8·373242	8·373776	8·374310	8·374843		38
	22	377499	378028	378557	379084	379612	380138		37
	23	382762	383285	383807	384329	384850	385370		36
	24	387962	388479	388995	389510	390025	390539		35
	25	393101	393611	394121	394631	395139	395647		34
	26	398179	398684	399188	399691	400194	400696		33
	27	403199	403698	404196	404694	405191	405687		32
	28	408161	408654	409147	409639	410130	410621		31
	29	413068	413555	414042	414529	415015	415500		30
	30	417919	418401	418883	419364	419844	420324	88	29
								°	′
		1·0	·9	·8	·7	·6	·5		

Log. Cosines.

TABLE IV.—Logarithmic Sines.

		·6	·7	·8	·9	1·0		
°	′							
0	45	8·122678	8·123629	8·124579	8·125526	8·126471	89	14
	46	132099	133030	133959	134885	135810		13
	47	141319	142231	143140	144048	144953		12
	48	150348	151241	152131	153020	153907		11
	49	159193	160067	160940	161811	162681		10
	50	167861	168718	169574	·70428	171280		9
	51	176359	177200	178039	·78877	179713		8
	52	184695	185520	186343	187165	187985		7
	53	192873	193683	194491	195297	196102	89	6
0	54	8·200900	8·201695	8·202488	8·203280	8·204070		5
	55	208782	209562	210341	211119	211895		4
	56	216523	217289	218055	218819	219581		3
	57	224128	224881	225634	226384	227133		2
	58	231603	232343	233082	233820	234557		1
	59	238951	239679	240405	241131	241855	89	0
1	0	246176	246892	247607	248321	249033		59
	1	253284	253988	254691	255393	256094		58
	2	260276	260970	261662	262352	263042	88	57
1	3	8·267158	8·267841	8·268522	8·269202	8·269881		56
	4	273933	274605	275275	275945	276614		55
	5	280604	281265	281925	282585	283243		54
	6	287173	287825	288475	289125	289773		53
	7	293645	294287	294928	295568	296207		52
	8	300021	300654	301286	301916	302546		51
	9	306306	306929	307552	308173	308794		50
	10	312500	313115	313729	314342	314954		49
	11	318608	319214	319819	320423	321027	88	48
1	12	8·324630	8·325228	8·325825	8·326421	8·327016		47
	13	330571	331160	331749	332337	332924		46
	14	336431	337012	337593	338174	338753		45
	15	342213	342787	343360	343933	344504		44
	16	347919	348485	349051	349616	350180		43
	17	353551	354110	354669	355226	355783		42
	18	359111	359663	360214	360765	361315		41
	19	364600	365145	365690	366234	366777		40
	20	370021	370560	371095	371635	372171	88	39
1	21	8·375375	8·375907	8·376438	8·376969	8·377499		38
	22	380664	381190	381714	382239	382762		37
	23	385889	386409	386927	387445	387962		36
	24	391053	391566	392078	392590	393101		35
	25	396155	396662	397168	397674	398179		34
	26	401198	401699	402200	402700	403199		33
	27.	406183	406679	407173	407668	408161		32
	28	411112	411601	412091	412579	413068		31
	29	415985	416469	416953	417436	417919		30
	30	420804	421283	422762	422239	422717	88	29
							°	′
		·4	·3	·2	·1	·0		

Log. Cosines.

0 Deg.	TABLE V.—Log. Sines, etc.							0¾ Deg.
° ′	Sine	Cosec.	Tang.	Cotang.	Sec.	D.	Cosine	
					10·00			
0 0	0·000000	Infinite.	0·000000	Infinite.	0000		10·000000	60
1	6·463726	13·536274	6·463726	13·536274	0000	0	0000	59
2	764756	235244	764756	235244	0000	0	0000	58
3	940847	059153	940847	059153	0000	0	0000	57
4	7·065786	12·934214	7·065786	12·934214	0000	0	0000	56
5	162696	837304	162696	837304	0000	0	0000	55
6	241877	758123	241878	758122	0001	1	9·999999	54
7	308824	691176	308825	691175	0001	1	9999	53
8	366816	633184	366817	633183	0001	1	9999	89 52
0 9	7·417968	12·582032	7·417970	12·582030	0001		9·999999	51
10	463725	536275	463727	536273	0002	1	9998	50
11	505118	494882	505120	494880	0002	1	9998	49
12	542906	457094	542909	457091	0003	1	9997	48
13	577668	422332	577672	422328	0003	1	9997	47
14	609853	390147	609857	390143	0004	1	9996	46
15	639816	360184	639820	360180	0004	1	9996	45
16	667845	332155	667849	332151	0005	1	9995	44
17	694173	305827	694179	305821	0005	1	9995	89 43
0 18	7·718997	12·281003	7·719003	12·280997	0006		9·999994	42
19	742477	257523	742484	257516	0007	1	9993	41
20	764754	235246	764761	235239	0007	1	9993	40
21	785943	214057	785951	214049	0008	1	9992	39
22	806146	193854	806155	193845	0009	1	9991	38
23	825451	174549	825460	174540	0010	1	9990	37
24	843934	156066	843944	156056	0011	1	9989	36
25	861662	138338	861674	138326	0011	2	9989	35
26	878695	121305	878708	121292	0012	2	9988	89 34
0 27	7·895085	12·104915	7·895099	12·104901	0013		9·999987	33
28	910879	089121	910894	089106	0014	2	9986	32
29	926119	073881	926134	073866	0015	2	9985	31
30	940842	059158	940858	059142	0017	2	9983	30
31	955082	044918	955100	044900	0018	2	9982	29
32	968870	031130	968889	031111	0019	2	9981	28
33	982233	017767	982253	017747	0020	2	9980	27
34	995198	004802	995219	004781	0021	2	9979	26
35	8·007787	11·992213	8·007809	11·992191	0023	2	9977	89 25
0 36	8·020021	11·979979	8·020045	11·979955	0024		9·999976	24
37	031919	968081	031945	968055	0025	2	9975	23
38	043501	956499	043527	956473	0027	2	9973	22
39	054781	945219	054809	945191	0028	2	9972	21
40	065776	934224	065806	934194	0029	2	9971	20
41	076500	923500	076531	923469	0031	2	9969	19
42	086965	913035	086997	913003	0032	2	9968	18
43	097183	902817	097217	902783	0034	2	9966	17
44	107167	892833	107202	892798	0036	2	9964	16
45	116926	883074	116963	883037	0037	3	9963	**89** 15
	Cosine	Secant	Cotang.	Tang.	Cos.	D.	Sine	° ′
90 Deg.								89¼ Deg.

0¾ Deg.	TABLE V.—Log. Sines, etc.							1½ Deg.
° ′	Sine	Cosec.	Tang.	Cotang.	Sec.	D.	Cosine	
					10·00			
0 45	8·116926	11·883074	8·116963	11·883037	0037		9·999963	15
46	126471	873529	126510	873490	0039	3	9961	14
47	135810	864190	135851	864149	0041	3	9959	13
48	144953	855047	144996	855004	0042	3	9958	12
49	153907	846093	153952	846048	0044	3	9956	11
50	162681	837319	162727	837273	0046	3	9954	10
51	171280	828720	171328	828672	0048	3	9952	9
52	179713	820287	179763	820237	0050	3	9950	8
53	187985	812015	188036	811964	0052	3	9948	89 7
0 54	8·196102	11·803898	8·196156	11·803844	0054	3	9·999946	6
55	204070	795930	204126	795874	0056	3	0044	5
56	211895	788105	211953	788047	0058	4	9942	4
57	219581	780419	219641	780359	0060	4	9940	3
58	227134	772866	227195	772805	0062	4	9938	2
59	234557	765443	234621	765379	0064	4	9936	1
1 0	241855	758145	241921	758079	0066	4	9934	**89** 0
1	249033	750967	249102	750898	0068	4	9932	59
2	256094	743906	256165	743835	0071	4	9929	88 58
1 3	8·263042	11·736958	8·263115	11·736885	0073	4	9·999927	57
4	269881	730119	269956	730044	0075	4	9925	56
5	276614	723386	276691	723309	0078	4	9922	55
6	283243	716757	283323	716677	0080	4	9920	54
7	289773	710227	289856	710144	0082	4	9918	53
8	296207	703793	196292	703708	0085	4	9915	52
9	302546	697454	302634	697366	0087	4	9913	51
10	308794	691206	308884	691116	0090	4	9910	50
11	314954	685046	315046	684954	0093	4	9907	88 49
1 12	8·321027	11·678973	8·321122	11·678878	0095	4	9·999905	48
13	327016	672984	327114	672886	0098	4	9902	47
14	332924	667076	333025	666975	0101	4	9899	46
15	338753	661247	338856	661144	0103	5	9897	45
16	344504	655496	344610	655390	0106	5	9894	44
17	350181	649819	350289	649711	0109	5	9891	43
18	355783	644217	355895	644105	0112	5	9888	42
19	361315	638685	361430	638570	0115	5	9885	41
20	366777	633223	366895	633105	0118	5	9882	88 40
1 21	8·372171	11·627829	8·372292	11·627708	0121	5	9·999879	39
22	377499	622501	377622	622378	0124	5	9876	38
23	382762	617238	382889	617111	0127	5	9873	37
24	387962	612038	388092	611908	0130	5	9870	36
25	393101	606899	393234	606766	0133	5	9867	35
26	398179	601821	398315	601685	0136	5	9864	34
27	403199	596801	403338	596662	0139	5	9861	33
28	408161	591839	408304	591696	0142	5	9858	32
29	413068	586932	413213	586787	0146	5	9854	31
30	417919	582081	418068	581932	0149	5	9851	**88** 30
	Cosine	Secant	Cotang.	Tang.	Cos.	D.	Sine	° ′
89¼ Deg.								88½ Deg.

1½ Deg.	TABLE V.—Log. Sines, etc.									2¼ Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	8·		11·	8·		11·	10·00		9·99	
1 30	417919	7996	582081	418068	8002	581932	0149	6	9851	30
31	422717	7909	577283	422869	7914	577131	0152	6	9848	29
32	427462	7823	572538	427618	7828	572382	0156	6	9844	28
33	432156	7740	567844	432315	7745	567685	0159	6	9841	27
34	436800	7657	563200	436962	7663	563038	0162	6	9838	26
35	441394	7577	558606	441560	7583	558440	0166	6	9834	25
36	445941	7499	554059	446110	7505	553890	0169	6	9831	24
37	450440	7422	549560	450613	7428	549387	0173	6	9827	23
38	454893	7346	545107	455070	7352	544930	0177	6	9823	88 22
1 39	459301	7273	540699	459481	7279	540519	0180	6	9820	21
40	463665	7200	536335	463849	7206	536151	0184	6	9816	20
41	467985	7129	532015	468172	7135	531828	0188	6	9812	19
42	472263	7060	527737	472454	7066	527546	0191	6	9809	18
43	476498	6991	523502	476693	6998	523307	0195	6	9805	17
44	480693	6924	519307	480892	6931	519108	0199	6	9801	16
45	484848	6859	515152	485050	6865	514950	0203	7	9797	15
46	488963	6794	511037	489170	6801	510830	0207	7	9793	14
47	493040	6731	506960	493250	6738	506750	0210	7	9790	88 13
1 48	497078	6669	502922	497293	6676	502707	0214	7	9786	12
49	501080	6608	498920	501298	6615	498702	0218	7	9782	11
50	505045	6548	494955	505267	6555	494733	0222	7	9778	10
51	508974	6489	491026	509200	6496	490800	0226	7	9774	9
52	512867	6432	487133	513098	6439	486902	0231	7	9769	8
53	516726	6375	483274	516961	6382	483039	0235	7	9765	7
54	520551	6319	479449	520790	6326	479210	0239	7	9761	6
55	524343	6264	475657	524586	6272	475414	0243	7	9757	5
56	528102	6211	471898	528349	6218	471651	0247	7	9753	88 4
1 57	531828	6158	468172	532080	6165	467920	0252	7	9748	3
58	535523	6106	464477	535779	6113	464221	0256	7	9744	2
59	539186	6055	460814	539447	6062	460553	0260	7	9740	1
2 0	542819	6004	457181	543084	6012	456916	0265	7	9735	88 0
1	546422	5955	453578	546691	5962	453309	0269	7	9731	59
2	549995	5906	450005	550268	5914	449732	0274	7	9726	58
3	553539	5858	446461	553817	5866	446183	0278	8	9722	57
4	557054	5811	442946	557336	5819	442664	0283	8	9717	56
5	560540	5765	439460	560828	5773	439172	0287	8	9713	87 55
2 6	563999	5719	436001	564291	5727	435709	0292	8	9708	54
7	567431	5674	432569	567727	5682	432273	0296	8	9704	53
8	570836	5630	429164	571137	5638	428863	0301	8	9699	52
9	574214	5587	425786	574520	5595	425480	0306	8	9694	51
10	577566	5544	422434	577877	5552	422123	0311	8	9689	50
11	580892	5502	419108	581208	5510	418792	0315	8	9685	49
12	584193	5460	415807	584514	5468	415486	0320	8	9680	48
13	587469	5419	412531	587795	4427	412205	0325	8	9675	47
14	590721	5379	409279	591051	5387	408949	0330	8	9670	46
15	593948		406052	594283		405717	0335		9665	87 45
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
88½ Deg.										87¾ Deg.

2¼ Deg.	TABLE V.—Log. Sines, etc.									3 Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	8·		11·	8·		11·	10·00		9·99	
2 15	593948	5339	406052	594283	5347	405717	0335	8	9665	45
16	597152	5300	402848	597492	5308	402508	0340	8	9660	44
17	600332	5261	399668	600677	5270	399323	0345	8	9655	43
18	603489	5223	396511	603839	5232	396161	0350	8	9650	42
19	606623	5186	393377	606978	5194	393022	0355	8	9645	41
20	609734	5149	390266	610094	5158	389906	0360	9	9640	40
21	612823	5112	387177	613189	5121	386811	0365	9	9635	39
22	615891	5076	384109	616262	5085	383738	0371	9	9629	38
23	618937	5041	381063	619313	5050	380687	0376	9	9624	87 37
2 24	621962	5006	378038	622343	5015	377657	0381	9	9619	36
25	624965	4972	375035	625352	4981	374648	0386	9	9614	35
26	627948	4938	372052	628340	4947	371660	0392	9	9608	34
27	630911	4904	369089	631308	4913	368692	0397	9	9603	33
28	633854	4871	366146	634256	4880	365744	0403	9	9597	32
29	636776	4839	363224	637184	4848	362816	0408	9	9592	31
30	639680	4806	360320	640093	4816	359907	0414	9	9586	30
31	642563	4775	357437	642982	4784	357018	0419	9	9581	29
32	645428	4743	354572	645853	4753	354147	0425	9	9575	87 28
2 33	648274	4712	351726	648704	4722	351296	0430	9	9570	27
34	651102	4682	348898	651537	4691	348463	0436	9	9564	26
35	653911	4652	346089	654352	4661	345648	0442	10	9558	25
36	656702	4622	343298	657149	4631	342851	0447	10	9553	24
37	659475	4592	340525	659928	4602	340072	0453	10	9547	23
38	662230	4563	337770	662689	4573	337311	0459	10	9541	22
39	664968	4535	335032	665433	4544	334567	0465	10	9535	21
40	667689	4506	332311	668160	4517	331840	0471	10	9529	20
41	670393	4479	329607	670870	4488	329130	0476	10	9524	87 19
2 42	673080	4451	326920	673563	4461	326437	0482	10	9518	18
43	675751	4424	324249	676239	4434	323761	0488	10	9512	17
44	678405	4397	321595	678900	4407	321100	0494	10	9506	16
45	681043	4370	318957	681544	4380	318456	0500	10	9500	15
46	683665	4344	316335	684172	4354	315828	0507	10	9493	14
47	686272	4318	313728	686784	4328	313216	0513	10	9487	13
48	688863	4292	311137	689381	4303	310619	0519	10	9481	12
49	691438	4267	308562	691963	4277	308037	0525	10	9475	11
50	693998	4242	306002	694529	4252	305471	0531	10	9469	87 10
2 51	696543	4217	303457	697081	4228	302919	0537	11	9463	9
52	699073	4192	300927	699617	4203	300383	0544	11	9456	8
53	701589	4168	298411	702139	4179	297861	0550	11	9450	7
54	704090	4144	295910	704646	4155	295354	0557	11	9443	6
55	706577	4121	293423	707140	4132	292860	0563	11	9437	5
56	709049	4097	290951	709618	4108	290382	0569	11	9431	4
57	711507	4074	288493	712083	4085	287917	0576	11	9424	3
58	713952	4051	286048	714534	4062	285466	0582	11	9418	2
59	716383	4029	283617	716972	4040	283028	0589	11	9411	1
60	718800		281200	719396		280604	0596		9404	87 0
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
87¾ Deg.										87 Deg.

3 Deg.	TABLE V.—Log. Sines, etc.									3¾ Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	8·		11·	8·		11·	10·00		9·99	
3 0	718800	4006	281200	719396	4017	280604	0596	11	9404	87 0
1	721204	3984	278796	721806	3995	278194	0602	11	9398	59
2	723595	3962	276405	724204	3974	275796	0609	11	9391	58
3	725972	3941	274028	726588	3952	273412	0616	11	9384	57
4	728337	3919	271663	728959	3930	271041	0622	11	9378	56
5	730688	3898	269312	731317	3909	268683	0629	11	9371	55
6	733027	3877	266973	733663	3889	266337	0636	12	9364	54
7	735354	3857	264646	735996	3868	264004	0643	12	9357	53
8	737667	3836	262333	738317	3848	261683	0650	12	9350	86 52
3 9	739969	3816	260031	740626	3827	259374	0657	12	9343	51
10	742259	3796	257741	742922	3807	257078	0664	12	9336	50
11	744536	3776	255464	745207	3787	254793	0671	12	9329	49
12	746802	3756	253198	747479	3768	252521	0678	12	9322	48
13	749055	3737	250945	749740	3749	250260	0685	12	9315	47
14	751297	3717	248703	751989	3729	248011	0692	12	9308	46
15	753528	3698	246472	754227	3710	245773	0699	12	9301	45
16	755747	3678	244253	756453	3692	243547	0706	12	9294	44
17	757955	3661	242045	758668	3673	241332	0714	12	9286	86 43
3 18	760151	3642	239849	760872	3655	239128	0721	12	9279	42
19	762337	3624	237663	763065	3636	236935	0728	12	9272	41
20	764511	3606	235489	765246	3618	234754	0735	12	9265	40
21	766675	3588	233325	767417	3600	232583	0743	12	9257	39
22	768828	3570	231172	769578	3583	230422	0750	13	9250	38
23	770970	3553	229030	771727	3565	228273	0758	13	9242	37
24	773101	3535	226899	773866	3548	226134	0765	13	9235	36
25	775223	3518	224777	775995	3531	224005	0773	13	9227	35
26	777333	3501	222667	778114	3514	221886	0780	13	9220	86 34
3 27	779434	3484	220566	780222	3497	219778	0788	13	9212	33
28	781524	3467	218476	782320	3480	217680	0795	13	9205	32
29	783605	3451	216395	784408	3464	215592	0803	13	9197	31
30	785675	3434	214325	786486	3447	213514	0811	13	9189	30
31	787736	3418	212264	788554	3431	211446	0819	13	9181	29
32	789787	3402	210213	790613	3415	209387	0826	13	9174	28
33	791828	3386	208172	792662	3399	207338	0834	13	9166	27
34	793859	3370	206141	794701	3383	205299	0842	13	9158	26
35	795881	3354	204119	796731	3368	203269	0850	13	9150	86 25
3 36	797894	3339	202106	798752	3352	201248	0858	13	9142	24
37	799897	3323	200103	800763	3337	199237	0866	13	9134	23
38	801892	3308	198108	802765	3322	197235	0874	13	9126	22
39	803876	3293	196124	804758	3307	195242	0882	13	9118	21
40	805852	3278	194148	806742	3292	193258	0890	13	9110	20
41	807819	3263	192181	808717	3277	191283	0898	13	9102	19
42	809777	3249	190223	810683	3262	189317	0906	14	9094	18
43	811726	3234	188274	812641	3248	187359	0914	14	9086	17
44	813667	3219	186333	814589	3233	185411	0923	14	9077	16
45	815599		184401	816529		183471	0931		9069	86 15
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
87 Deg.										86¼ Deg.

3¾ Deg.		TABLE V.—Log. Sines, etc.								4¼ Deg	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		8·		11·	8·		11·	10·00		9·99	
3	45	815599		184401	816529		183471	0931		9069	15
	46	817522	3205	182478	818461	3219	181539	0939	14	9061	14
	47	819436	3191	180564	820384	3205	179616	0947	14	9053	13
	48	821343	3177	178657	822298	3191	177702	0956	14	9044	12
	49	823240	3163	176760	824205	3177	175795	0964	14	9036	11
	50	825130	3149	174870	826103	3163	173897	0973	14	9027	10
	51	827011	3135	172989	827992	3150	172008	0981	14	9019	9
	52	828884	3122	171116	829874	3136	170126	0990	14	9010	8
	53	830749	3108	169251	831748	3123	168252	0998	14	9002	86 7
3	54	832607	3095	167393	833613	3108	166387	1007	14	8993	6
	55	834456	3082	165544	835471	3096	164529	1016	14	8984	5
	56	836297	3069	163703	837321	3083	162679	1024	14	8976	4
	57	838130	3056	161870	839163	3070	160837	1033	14	8967	3
	58	839956	3043	160044	840998	3057	159002	1042	15	8958	2
	59	841774	3030	158226	842825	3045	157175	1050	15	8950	1
4	0	843585	3017	156415	844644	3032	155356	1059	15	8941	**86** 0
	1	845387	3005	154613	846455	3019	153545	1068	15	8932	59
	2	847183	2992	152817	848260	3007	151740	1077	15	8923	58
4	3	848971	2980	151029	850057	2995	149943	1086	15	8914	57
	4	850751	2967	149249	851846	2982	148154	1095	15	8905	56
	5	852525	2955	147475	853628	2970	146372	1104	15	8896	55
	6	854291	2943	145709	855403	2958	144597	1113	15	8887	54
	7	856049	2931	143951	857171	2946	142829	1122	15	8878	53
	8	857801	2919	142199	858932	2935	141068	1131	15	8869	52
	9	859546	2908	140454	860686	2923	139314	1140	15	8860	51
	10	861283	2896	138717	862433	2911	137567	1149	15	8851	50
	11	863014	2884	136986	864173	2900	135827	1159	15	8841	85 49
4	12	864738	2873	135262	865906	2888	134094	1168	15	8832	48
	13	866455	2861	133545	867632	2877	132368	1177	15	8823	47
	14	868165	2850	131835	869351	2866	130649	1187	16	8813	46
	15	869868	2839	130132	871064	2854	128936	1196	16	8804	45
	16	871565	2828	128435	872770	2843	127230	1205	16	8795	44
	17	873255	2817	126745	874469	2832	125531	1215	16	8785	43
	18	874938	2806	125062	876162	2821	123838	1224	16	8776	42
	19	876615	2795	123385	877849	2811	122151	1234	16	8766	41
	20	878285	2783	121715	879529	2800	120471	1243	16	8757	85 40
4	21	879949	2773	120051	881202	2789	118798	1253	16	8747	39
	22	881607	2763	118393	882869	2779	117131	1262	16	8738	38
	23	883258	2752	116742	884530	2768	115470	1272	16	8728	37
	24	884903	2742	115097	886185	2758	113815	1282	16	8718	36
	25	886542	2731	113458	887833	2747	112167	1292	16	8708	35
	26	888174	2721	111826	889476	2737	110524	1301	16	8699	34
	27	889801	2711	110199	891112	2727	108888	1311	16	8689	33
	28	891421	2700	108579	892742	2717	107258	1321	16	8679	32
	29	893035	2690	106965	894366	2707	105634	1331	16	8669	31
	30	894643	2680	105357	895984	2697	104016	1341	17	8659	**85** 30
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
86¼ Deg.											85½ Deg.

4½ Deg.	TABLE V.—Log. Sines, etc.									5¼ Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	8·		11·	8·		11·	10·00		9·99	
4 30	894643	2670	105357	895984	2687	104016	1341	17	8659	30
31	896246	2660	103754	897596	2677	102404	1351	17	8649	29
32	897842	2651	102158	899203	2667	100797	1361	17	8639	28
33	899432	2641	100568	900803	2658	099197	1371	17	8629	27
34	901017	2631	098983	902398	2648	097602	1381	17	8619	26
35	902596	2622	097404	903987	2638	096013	1391	17	8609	25
36	904169	2612	095831	905570	2629	094430	1401	17	8599	24
37	905736	2603	094264	907147	2620	092853	1411	17	8589	23
38	907297	2593	092703	908719	2610	091281	1422	17	8578	85 22
4 39	908853	2584	091147	910285	2601	089715	1432	17	8568	21
40	910404	2575	089596	911846	2592	088154	1442	17	8558	20
41	911949	2566	088051	913401	2583	086599	1452	17	8548	19
42	913488	2556	086512	914951	2574	085049	1463	17	8537	18
43	915022	2547	084978	916495	2565	083505	1473	17	8527	17
44	916550	2538	083450	918034	2556	081966	1484	18	8516	16
45	918073	2529	081927	919568	2547	080432	1494	18	8506	15
46	919591	2520	080409	921096	2538	078904	1505	18	8495	14
47	921103	2512	078897	922619	2530	077381	1515	18	8485	85 13
4 48	922610	2503	077390	924136	2521	075864	1526	18	8474	12
49	924112	2494	075888	925649	2512	074351	1536	18	8464	11
50	925609	2486	074391	927156	2503	072844	1547	18	8453	10
51	927100	2477	072900	928658	2495	071342	1558	18	8442	9
52	928587	2469	071413	930155	2486	069845	1569	18	8431	8
53	930068	2460	069932	931647	2478	068353	1579	18	8421	7
54	931544	2452	068456	933134	2470	066866	1590	18	8410	6
55	933015	2443	066985	934616	2461	065384	1601	18	8399	5
56	934481	2435	065519	936093	2453	063907	1612	18	8388	85 4
4 57	935942	2427	064058	937565	2445	062435	1623	18	8377	3
58	937398	2419	062602	939032	2437	060968	1634	18	8366	2
59	938850	2411	061150	940494	2430	059506	1645	18	8355	1
5 0	940296	2403	059704	941952	2421	058048	1656	18	8344	8 0
1	941738	2394	058262	943404	2413	056596	1667	19	8333	59
2	943174	2387	056826	944852	2405	055148	1678	19	8322	58
3	944606	2379	055394	946295	2397	053705	1689	19	8311	57
4	946034	2371	053966	947734	2390	052266	1700	19	8300	56
5	947456	2363	052544	949168	2382	050832	1711	19	8289	84 55
5 6	948874	2355	051126	950597	2374	049403	1723	19	8277	54
7	950287	2348	049713	952021	2366	047979	1734	19	8266	53
8	951696	2340	048304	953441	2358	046559	1745	19	8255	52
9	953100	2332	046900	954856	2351	045144	1757	19	8243	51
10	954499	2325	045501	956267	2344	043733	1768	19	8232	50
11	955894	2317	044106	957674	2335	042326	1780	19	8220	49
12	957284	2310	042716	959075	2329	040925	1791	19	8209	48
13	958670	2302	041330	960473	2321	039527	1803	19	8197	47
14	960052	2295	039948	961866	2314	038134	1814	19	8186	46
15	961429		038571	963255		036745	1826	19	8174	84 45
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
85½ Deg.										84¾ Deg.

5¼ Deg.	TABLE V.—Log. Sines, etc.									6 Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	8·		11·	8·		11·	10·00		9·99	
5 15	961429	2288	038571	963255	2307	036745	1826	19	8174	45
16	962801	2280	037199	964639	2300	035361	1837	19	8163	44
17	964170	2273	035830	966019	2293	033981	1849	19	8151	43
18	965534	2266	034466	967394	2286	032606	1861	20	8139	42
19	966893	2259	033107	968766	2279	031234	1872	20	8128	41
20	968249	2252	031751	970133	2271	029867	1884	20	8116	40
21	969600	2245	030400	971496	2265	028504	1896	20	8104	39
22	970947	2238	029053	972855	2257	027145	1908	20	8092	38
23	972289	2231	027711	974209	2251	025791	1920	20	8080	84 37
5 24	973628	2224	026372	975560	2244	024440	1932	20	8068	36
25	974962	2217	025038	976906	2237	023094	1944	20	8056	35
26	976293	2210	023707	978248	2230	021752	1956	20	8044	34
27	977619	2203	022381	979586	2223	020414	1968	20	8032	33
28	978941	2197	021059	980921	2217	019079	1980	20	8020	32
29	980259	2190	019741	982251	2210	017749	1992	20	8008	31
30	981573	2183	018427	983577	2204	016423	2004	20	7996	30
31	982883	2177	017117	984899	2197	015101	2016	20	7984	29
32	984189	2170	015811	986217	2191	013783	2028	20	7972	84 28
5 33	985491	2163	014509	987532	2184	012468	2041	20	7959	27
34	986789	2157	013211	988842	2178	011158	2053	20	7947	26
35	988083	2150	011917	990149	2171	009851	2065	21	7935	25
36	989374	2144	010626	991451	2165	008549	2078	21	7922	24
37	990660	2138	009340	992750	2158	007250	2090	21	7910	23
38	991943	2131	008057	994045	2152	005955	2103	21	7897	22
39	993222	2125	006778	995337	2146	004663	2115	21	7885	21
40	994497	2119	005503	996624	2140	003376	2128	21	7872	20
41	995768	2112	004232	997908	2134	002092	2140	21	7860	84 19
5 42	997036	2106	002964	999188	2127	000812	2153	21	7847	18
43	998299	2100	001701	000465	2121	999535	2165	21	7835	17
44	999560	2094	000440	001738	2115	998262	2178	21	7822	16
45	000816	2088	999184	003007	2109	996993	2191	21	7809	15
46	002069	2082	997931	004272	2103	995728	2203	21	7797	14
47	003318	2076	996682	005534	2097	994466	2216	21	7784	13
48	004563	2070	995437	006792	2091	993208	2229	21	7771	12
49	005805	2064	994195	008047	2085	991953	2242	21	7758	11
50	007044	2058	992956	009298	2080	990702	2255	21	7745	84 10
5 51	008278	2052	991722	010546	2074	989454	2268	21	7732	9
52	009510	2046	990490	011790	2068	988210	2281	21	7719	8
53	010737	2040	989263	013031	2062	986969	2294	21	7706	7
54	011962	2034	988038	014268	2056	985732	2307	22	7693	6
55	013182	2029	986818	015502	2051	984498	2320	22	7680	5
56	014400	2023	985600	016732	2045	983268	2333	22	7667	4
57	015613	2017	984387	017959	2040	982041	2346	22	7654	3
58	016824	2012	983176	019183	2033	980817	2359	22	7641	2
59	018031	2006	981969	020403	2028	979597	2372	22	7628	1
60	019235		980765	021620		978380	2386		7614	**84** 0
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
84¾ Deg.										84 Deg.

6 Deg.		TABLE V.—Log. Sines, etc.								6¾ Deg.		
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.		
		9·		10·	9·		10·	10·00		9·99		
6	0	019235	2000	980765	021620	2023	978380	2386	22	7614		60
	1	020435	1995	979565	022834	2017	977166	2399	22	7601		59
	2	021632	1989	978368	024044	2011	975956	2412	22	7588		58
	3	022825	1984	977175	025251	2006	974749	2426	22	7574		57
	4	024016	1978	975984	026455	2000	973545	2439	22	7561		56
	5	025203	1973	974797	027655	1995	972345	2453	22	7547		55
	6	026386	1967	973614	028852	1990	971148	2466	23	7534		54
	7	027567	1962	972433	030046	1985	969954	2480	23	7520		53
	8	028744	1957	971256	031237	1979	968763	2493	23	7507	83	52
6	9	029918	1951	970082	032425	1974	967575	2507	23	7493		51
	10	031089	1946	968911	033609	1969	966391	2520	23	7480		50
	11	032257	1941	967743	034791	1964	965209	2534	23	7466		49
	12	033421	1936	966579	035969	1958	964031	2548	23	7452		48
	13	034582	1930	965418	037144	1953	962856	2561	23	7439		47
	14	035741	1925	964259	038316	1948	961684	2575	23	7425		46
	15	036896	1920	963104	039485	1943	960515	2589	23	7411		45
	16	038048	1915	961952	040651	1938	959349	2603	23	7397		44
	17	039197	1910	960803	041813	1933	958187	2617	23	7383	83	43
6	18	040342	1905	959658	042973	1928	957027	2631	23	7369		42
	19	041485	1899	958515	044130	1923	955870	2645	23	7355		41
	20	042625	1895	957375	045284	1918	954716	2659	23	7341		40
	21	043762	1889	956238	046434	1913	953566	2673	24	7327		39
	22	044895	1884	955105	047582	1908	952418	2687	24	7313		38
	23	046026	1879	953974	048727	1903	951273	2701	24	7299		37
	24	047154	1875	952846	049869	1898	950131	2715	24	7285		36
	25	048279	1870	951721	051008	1893	948992	2729	24	7271		35
	26	049400	1865	950600	052144	1889	947856	2743	24	7257	83	34
6	27	050519	1860	949481	053277	1884	946723	2758	24	7242		33
	28	051635	1855	948365	054407	1879	945593	2772	24	7228		32
	29	052749	1850	947251	055535	1874	944465	2786	24	7214		31
	30	053859	1845	946141	056659	1870	943341	2801	24	7199		30
	31	054966	1841	945034	057781	1865	942219	2815	24	7185		29
	32	056071	1836	943929	058900	1860	941100	2830	24	7170		28
	33	057172	1831	942828	060016	1855	939984	2844	24	7156		27
	34	058271	1827	941729	061130	1851	938870	2859	24	7141		26
	35	059367	1822	940633	062240	1846	937760	2873	24	7127	83	25
6	36	060460	1817	939540	063348	1842	936652	2888	24	7112		24
	37	061551	1813	938449	064453	1837	935547	2902	24	7098		23
	38	062639	1808	937361	065556	1833	934444	2917	25	7083		22
	39	063724	1804	936276	066655	1828	933345	2932	25	7068		21
	40	064806	1799	935194	067752	1824	932248	2947	25	7053		20
	41	065885	1794	934115	068846	1819	931154	2961	25	7039		19
	42	066962	1790	933038	069938	1815	930062	2976	25	7024		18
	43	068036	1786	931964	071027	1810	928973	2991	25	7009		17
	44	069107	1781	930893	072113	1806	927887	3006	25	6994		16
	45	070176		929824	073197		926803	3021	25	6979	83	15
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	°	′
84 Deg.											83¼ Deg.	

$6\frac{3}{4}$ Deg. TABLE V.—Log. Sines, etc. $7\frac{1}{2}$ Deg.

°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.		
		9·		10·	9·		10·	10·00		9·99		
6	45	070176	1777	929824	073197	1802	926803	3021	25	6979		15
	46	071242	1772	928758	074278	1797	925722	3036	25	6964		14
	47	072306	1768	927694	075356	1793	924644	3051	25	6949		13
	48	073366	1763	926634	076432	1789	923568	3066	25	6934		12
	49	074424	1759	925576	077505	1784	922495	3081	25	6919		11
	50	075480	1755	924520	078576	1780	921424	3096	25	6904		10
	51	076533	1750	923467	079644	1776	920356	3111	25	6889		9
	52	077583	1746	922417	080710	1772	919290	3126	25	6874		8
	53	078631	1742	921369	081773	1767	918227	3142	25	6858	83	7
6	54	079676	1738	920324	082833	1763	917167	3157	25	6843		6
	55	080719	1733	919281	083891	1759	916109	3172	25	6828		5
	56	081759	1729	918241	084947	1755	915053	3188	26	6812		4
	57	082797	1725	917203	086000	1751	914000	3203	26	6797		3
	58	083832	1721	916168	087050	1747	912950	3218	26	6782		2
	59	084864	1717	915136	088098	1743	911902	3234	26	6766		1
7	0	085894	1713	914106	089144	1738	910856	3249	26	6751	**83**	0
	1	086922	1709	913078	090187	1735	909813	3265	26	6735		59
	2	087947	1704	912053	091228	1731	908772	3280	26	6720	82	58
7	3	088970	1700	911030	092266	1727	907734	3296	26	6704		57
	4	089990	1696	910010	093302	1722	906698	3312	26	6688		56
	5	091008	1692	908992	094336	1719	905664	3327	26	6673		55
	6	092024	1688	907976	095367	1715	904633	3343	26	6657		54
	7	093037	1684	906963	096395	1711	903605	3359	26	6641		53
	8	094047	1680	905953	097422	1707	902578	3375	26	6625		52
	9	095056	1676	904944	098446	1703	901554	3390	26	6610		51
	10	096062	1673	903938	099468	1699	900532	3406	26	6594		50
	11	097065	1668	902935	100487	1695	899513	3422	27	6578	82	49
7	12	098066	1665	901934	101504	1691	898496	3438	27	6562		48
	13	099065	1661	900935	102519	1687	897481	3454	27	6546		47
	14	100062	1657	899938	103532	1684	896468	3470	27	6530		46
	15	101056	1653	898944	104542	1680	895458	3486	27	6514		45
	16	102048	1649	897952	105550	1676	894450	3502	27	6498		44
	17	103037	1645	896963	106556	1672	893444	3518	27	6482		43
	18	104025	1642	895975	107559	1669	892441	3535	27	6465		42
	19	105010	1638	894990	108560	1665	891440	3551	27	6449		41
	20	105992	1634	894008	109559	1661	890441	3567	27	6433	82	40
7	21	106973	1630	893027	110556	1658	889444	3583	27	6417		39
	22	107951	1627	892049	111551	1654	888449	3600	27	6400		38
	23	108927	1623	891073	112543	1650	887457	3616	27	6384		37
	24	109901	1619	890099	113533	1647	886467	3632	27	6368		36
	25	110873	1616	889127	114521	1643	885479	3649	27	6351		35
	26	111842	1612	888158	115507	1639	884493	3665	27	6335		34
	27	112809	1608	887191	116491	1636	883509	3682	27	6318		33
	28	113774	1605	886226	117472	1632	882528	3698	28	6302		32
	29	114737	1601	885263	118452	1629	881548	3715	28	6285		31
	30	115698		884302	119429		880571	3731		6269	**82**	30
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	°	′

$83\frac{1}{4}$ Deg. $82\frac{1}{2}$ Deg.

7½ Deg.	TABLE V.—Log. Sines, etc.									8¼ Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9′		10′	9′		10′	10·00		9·99	
7 30	115698		884302	119429		880571	3731		6269	30
31	116656	1597	883344	120404	1625	879596	3748	28	6252	29
32	117613	1594	882387	121377	1622	878623	3765	28	6235	28
33	118567	1590	881433	122348	1618	877652	3781	28	6219	27
34	119519	1587	880481	123317	1615	876683	3798	28	6202	26
35	120469	1583	879531	124284	1611	875716	3815	28	6185	25
36	121417	1580	878583	125249	1608	874751	3832	28	6168	24
37	122362	1576	877638	126211	1604	873789	3849	28	6151	23
38	123306	1573	876694	127172	1601	872828	3866	28	6134	82 22
7 39	124248	1569	875752	128130	1597	871870	3883	28	6117	21
40	125187	1566	874813	129087	1594	870913	3900	28	6100	20
41	126125	1562	873875	130041	1591	869959	3917	29	6083	19
42	127060	1559	872940	130994	1587	869006	3934	29	6066	18
43	127993	1556	872007	131944	1584	868056	3951	29	6049	17
44	128925	1552	871075	132893	1581	867107	3968	29	6032	16
45	129854	1549	870146	133839	1577	866161	3985	29	6015	15
46	130781	1545	869219	134784	1574	865216	4002	29	5998	14
47	131706	1542	868294	135726	1571	864274	4020	29	5980	82 13
7 48	132630	1539	867370	136667	1567	863333	4037	29	5963	12
49	133551	1535	866449	137605	1564	862395	4054	29	5946	11
50	134470	1532	865530	138542	1561	861458	4072	29	5928	10
51	135387	1529	864613	139476	1558	860524	4089	29	5911	9
52	136303	1525	863697	140409	1555	859591	4106	29	5894	8
53	137216	1522	862784	141340	1551	858660	4124	29	5876	7
54	138128	1519	861872	142269	1548	857731	4141	29	5859	6
55	139037	1516	860963	143196	1545	856804	4159	29	5841	5
56	139944	1512	860056	144121	1542	855879	4177	29	5823	82 4
7 57	140850	1509	859150	145044	1539	854956	4194	29	5806	3
58	141754	1506	858246	145966	1535	854034	4212	29	5788	2
59	142655	1503	857345	146885	1532	853115	4229	29	5771	**82** 1
8 0	143555	1500	856445	147803	1529	852197	4247	29	5753	0
1	144453	1496	855547	148718	1526	851282	4265	30	5735	59
2	145349	1493	854651	149632	1523	850368	4283	30	5717	58
3	146243	1490	853757	150544	1520	849456	4301	30	5699	57
4	147136	1487	852864	151454	1517	848546	4319	30	5681	56
5	148026	1484	851974	152363	1514	847637	4336	30	5664	81 55
8 6	148915	1481	851085	153269	1511	846731	4354	30	5646	54
7	149802	1478	850198	154174	1508	845826	4372	30	5628	53
8	150686	1475	849314	155077	1505	844923	4390	30	5610	52
9	151569	1472	848431	155978	1502	844022	4409	30	5591	51
10	152451	1469	847549	156877	1499	843123	4427	30	5573	50
11	153330	1466	846670	157775	1496	842225	4445	30	5555	49
12	154208	1463	845792	158671	1493	841329	4463	30	5537	48
13	155083	1460	844917	159565	1490	840435	4481	30	5519	47
14	155957	1457	844043	160457	1487	839543	4499	30	5501	46
15	156830	1454	843170	161347	1484	838653	4518	31	5482	**81** 45
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
82½ Deg.										81¾ Deg.

8¼ Deg.	TABLE V.—Log Sines, etc.									9 Deg
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9·		10·	9·		10·	10·00		9·99	
8 15	156830	1451	843170	161347	1481	838653	4518	31	5482	45
16	157700	1448	842300	162236	1479	837764	4536	31	5464	44
17	158569	1445	841431	163123	1476	836877	4554	31	5446	43
18	159435	1442	840565	164008	1473	835992	4573	31	5427	42
19	160301	1439	839699	164892	1470	835108	4591	31	5409	41
20	161164	1436	838836	165774	1467	834226	4610	31	5390	40
21	162025	1433	837975	166654	1464	833346	4628	31	5372	39
22	162885	1430	837115	167532	1461	832468	4647	31	5353	38
23	163743	1427	836257	168409	1458	831591	4666	31	5534	81 37
8 24	164600	1424	835400	189284	1455	830716	4684	31	5316	36
25	165454	1422	834546	170157	1453	829843	4703	31	5297	35
26	166307	1419	833693	171029	1450	828971	4722	31	5278	34
27	167159	1416	832841	171899	1447	828101	4740	31	5260	33
28	168008	1413	831992	172767	1444	827233	4759	32	5241	32
29	168856	1410	831144	173634	1442	826366	4778	32	5222	31
30	169702	1407	830298	174499	1439	825501	4797	32	5203	30
31	170547	1405	829453	175362	1436	824638	4816	32	5184	29
32	171389	1402	828611	176224	1433	823776	4835	32	5165	81 28
8 33	172230	1399	827770	177084	1431	822916	4854	32	5146	27
34	173070	1396	826930	177942	1428	822058	4873	32	5127	26
35	173908	1394	826092	178799	1425	821201	4892	32	5108	25
36	174744	1391	825256	179655	1423	820345	4911	32	5089	24
37	175578	1388	824422	180508	1420	819492	4930	32	5070	23
38	176411	1386	823589	181360	1417	818640	4949	32	5051	22
39	177242	1383	822758	182211	1415	817789	4968	32	5032	21
40	178072	1380	821928	183059	1412	816941	4987	32	5013	20
41	178900	1377	821100	183907	1409	816093	5007	32	4993	81 19
8 42	179726	1374	820274	184752	1407	815248	5026	32	4974	18
43	180551	1372	819449	185597	1404	814403	5045	32	4955	17
44	181374	1369	818626	186439	1402	813561	5065	32	4935	16
45	182196	1366	817804	187280	1399	812720	5084	33	4916	15
46	183016	1364	816984	188120	1396	811880	5104	33	4896	14
47	183834	1361	816166	188958	1393	811042	5123	33	4877	13
48	184651	1359	815349	189794	1391	810206	5143	33	4857	12
49	185466	1356	814534	190629	1389	809371	5162	33	4838	11
50	186280	1353	813720	191462	1386	808538	5182	33	4818	81 10
8 51	187092	1351	812908	192294	1384	807706	5202	33	4798	9
52	187903	1348	812097	193124	1381	806876	5221	33	4779	8
53	188712	1346	811288	193953	1379	806047	5241	33	4759	7
54	189519	1343	810481	194780	1376	805220	5261	33	4739	6
55	190325	1341	809675	195606	1374	804394	5281	33	4719	5
56	191130	1338	808870	196430	1371	803570	5300	33	4700	4
57	191933	1336	808067	197253	1369	802747	5320	33	4680	3
58	192734	1333	807266	198074	1366	801926	5340	33	4660	2
59	193534	1330	806466	198894	1364	801106	5360	33	4640	1
60	194332		805668	199713		800287	5380	33	4620	**81** 0
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
8¾ Deg.										81 Deg.

9 Deg.		TABLE V.—Log. Sines, etc.								9¾ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·00		9·99	
9	0	194332	1328	805668	199713	1361	800287	5380	33	4620	60
	1	195129	1326	804871	200529	1359	799471	5400	33	4600	59
	2	195925	1323	804075	201345	1356	798655	5420	33	4580	58
	3	196719	1321	803281	202159	1354	797841	5440	34	4560	57
	4	197511	1318	802489	202971	1352	797029	5460	34	4540	56
	5	198302	1316	801698	203782	1349	796218	5481	34	4519	55
	6	199091	1313	800909	204592	1347	795408	5501	34	4499	54
	7	199879	1311	800121	205400	1345	794600	5521	34	4479	53
	8	200666	1308	799334	206207	1342	793793	5541	34	4459	80 52
9	9	201451	1306	798549	207013	1340	792987	5562	34	4438	51
	10	202234	1304	797766	207817	1338	792183	5582	34	4418	50
	11	203017	1301	796983	208619	1335	791381	5603	34	4397	49
	12	203797	1299	796203	209420	1333	790580	5623	34	4377	48
	13	204577	1296	795423	210220	1331	789780	5643	34	4357	47
	14	205354	1294	794646	211018	1328	788982	5664	34	4336	46
	15	206131	1292	793869	211815	1326	788185	5684	34	4316	45
	16	206906	1289	793094	212611	1324	787389	5705	34	4295	44
	17	207679	1287	792321	213405	1321	786595	5726	34	4274	80 43
9	18	208452	1285	791548	214198	1319	785802	5746	35	4254	42
	19	209222	1282	790778	214989	1317	785011	5767	35	4233	41
	20	209992	1280	790008	215780	1315	784220	5788	35	4212	40
	21	210760	1278	789240	216568	1312	783432	5809	35	4191	39
	22	211526	1275	788474	217356	1310	782644	5829	35	4171	38
	23	212291	1273	787709	218142	1308	781858	5850	35	4150	37
	24	213055	1271	786945	218926	1305	781074	5871	35	4129	36
	25	213818	1268	786182	219710	1303	780290	5892	35	4108	35
	26	214579	1266	785421	220492	1301	779508	5913	35	4087	80 34
9	27	215338	1264	784662	221272	1299	778728	5934	35	4066	33
	28	216097	1261	783903	222052	1297	777948	5955	35	4045	32
	29	216854	1259	783146	222830	1294	777170	5976	35	4024	31
	30	217609	1257	782391	223606	1292	776394	5997	35	4003	30
	31	218363	1255	781637	224382	1290	775618	6019	35	3981	29
	32	219116	1253	780884	225156	1288	774844	6040	35	3960	28
	33	219868	1250	780132	225929	1286	774071	6061	35	3939	27
	34	220618	1248	779382	226700	1284	773300	6082	35	3918	26
	35	221367	1246	778633	227471	1281	772529	6104	36	3896	80 25
9	36	222115	1244	777885	228239	1279	771761	6125	36	3875	24
	37	222861	1242	777139	229007	1277	770993	6146	36	3854	23
	38	223606	1239	776394	229773	1275	770227	6168	36	3832	22
	39	224349	1237	775651	230539	1273	769461	6189	36	3811	21
	40	225092	1235	774908	231302	1271	768698	6211	36	3789	20
	41	225833	1233	774167	232065	1269	767935	6232	36	3768	19
	42	226573	1231	773427	232826	1267	767174	6254	36	3746	18
	43	227311	1228	772689	233586	1265	766414	6275	36	3725	17
	44	228048	1226	771952	234345	1262	765655	6297	36	3703	16
	45	228784		771216	235103		764897	6319	36	3681	**80** 15
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	′
81 Deg.										80¼ Deg.	

9¾ Deg.	TABLE V.—Log. Sines, etc.									10½ Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9·		10·	9·		10·	10·00		9·99	
9 45	228784	1224	771216	235103	1260	764897	6319	36	3681	15
46	229518	1222	770482	235859	1258	764141	6340	36	3660	14
47	230252	1220	769748	236614	1256	763386	6362	36	3638	13
48	230984	1218	769016	237368	1254	762632	6384	36	3616	12
49	231714	1216	768286	238120	1252	761880	6406	37	3594	11
50	232444	1214	767556	238872	1250	761128	6428	37	3572	10
51	233172	1212	766828	239622	1248	760378	6450	37	3550	9
52	233899	1209	766101	240371	1246	759629	6472	37	3528	8
53	234625	1207	765375	241118	1244	758882	6494	37	3506	80 7
9 54	235349	1205	764651	241865	1242	758135	6516	37	3484	6
55	236073	1203	763927	242610	1240	757390	6538	37	3462	5
56	236795	1201	763205	243354	1238	756646	6560	37	3440	4
57	237515	1199	762485	244097	1236	755903	6582	37	3418	3
58	238235	1197	761765	244839	1234	755161	6604	37	3396	2
59	238953	1195	761047	245579	1232	754421	6626	37	3374	1
10 0	239670	1193	760330	246319	1230	753681	6649	37	3351	80 0
1	240386	1191	759614	247057	1228	752943	6671	37	3329	59
2	241101	1189	758899	247794	1226	752206	6693	37	3307	79 58
10 3	241814	1187	758186	248530	1224	751470	6715	37	3285	57
4	242526	1185	757474	249264	1222	750736	6738	37	3262	56
5	243237	1183	756763	249998	1220	750002	6760	37	3240	55
6	243947	1181	756053	250730	1218	749270	6783	37	3217	54
7	244656	1179	755344	251461	1217	748539	6805	38	3195	53
8	245363	1177	754637	252191	1215	747809	6828	38	3172	52
9	246069	1175	753931	252920	1213	747080	6851	38	3149	51
10	246775	1173	753225	253648	1211	746352	6873	38	3127	50
11	247478	1171	752522	254374	1209	745626	6896	38	3104	79 49
10 12	248181	1169	751819	255100	1207	744900	6919	38	3081	48
13	248883	1167	751117	255824	1205	744176	6941	38	3059	47
14	249583	1165	750417	256547	1203	743453	6964	38	3036	46
15	250282	1163	749718	257269	1201	742731	6987	38	3013	45
16	250980	1161	749020	257990	1200	742010	7010	38	2990	44
17	251677	1159	748323	258710	1198	741290	7033	38	2967	43
18	252373	1158	747627	259429	1196	740571	7056	38	2944	42
19	253067	1156	746933	260146	1194	739854	7079	38	2921	41
20	253761	1154	746239	260863	1192	739137	7102	38	2898	79 40
10 21	254453	1152	745547	261578	1190	738422	7125	38	2875	39
22	255144	1150	744856	262292	1189	737708	7148	38	2852	38
23	255834	1148	744166	263005	1187	736995	7171	39	2829	37
24	256523	1146	743477	263717	1185	736283	7194	39	2806	36
25	257211	1144	742789	264428	1183	735572	7217	39	2783	35
26	257898	1142	742102	265138	1181	734862	7241	39	2759	34
27	258583	1141	741417	265847	1179	734153	7264	39	2736	33
28	259268	1139	740732	266555	1178	733445	7287	39	2713	32
29	259951	1137	740049	267261	1176	732739	7310	39	2690	31
30	260633		739367	267967		732033	7334		2666	79 30
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
80¼ Deg.										79½ Deg.

10½ Deg.		TABLE V.—Log. Sines, etc.								11¼ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·00		9·99	
10	30	260633	1135	739367	267967	1174	732033	7334	39	2666	30
	31	261314	1133	738686	268671	1172	731329	7357	39	2643	29
	32	261994	1131	738006	269375	1170	730625	7381	39	2619	28
	33	262673	1130	737327	270077	1169	729923	7404	39	2596	27
	34	263351	1128	736649	270779	1167	729221	7428	39	2572	26
	35	264027	1126	735973	271479	1165	728521	7451	39	2549	25
	36	264703	1124	735297	272178	1164	727822	7475	39	2525	24
	37	265377	1122	734623	272876	1162	727124	7499	39	2501	23
	38	266051	1120	733949	273573	1160	726427	7522	40	2478	79 22
10	39	266723	1119	733277	274269	1158	725731	7546	40	2454	21
	40	267395	1117	732605	274964	1157	725036	7570	40	2430	20
	41	268065	1115	731935	275658	1155	724342	7594	40	2406	19
	42	268734	1113	731266	276351	1153	723649	7618	40	2382	18
	43	269402	1111	730598	277043	1151	722957	7641	40	2359	17
	44	270069	1110	729931	277734	1150	722266	7665	40	2335	16
	45	270735	1108	729265	278424	1148	721576	7689	40	2311	15
	46	271400	1106	728600	279113	1147	720887	7713	40	2287	14
	47	272064	1105	727936	279801	1145	720199	7737	40	2263	79 13
10	48	272726	1103	727274	280488	1143	719512	7761	40	2239	12
	49	273388	1101	726612	281174	1141	718826	7786	40	2214	11
	50	274049	1099	725951	281858	1140	718142	7810	40	2190	10
	51	274708	1098	725292	282542	1138	717458	7834	40	2166	9
	52	275367	1096	724633	283225	1136	716775	7858	40	2142	8
	53	276024	1094	723976	283907	1135	716093	7883	41	2117	7
	54	276681	1092	723319	284588	1133	715412	7907	41	2093	6
	55	277337	1091	722663	285268	1131	714732	7931	41	2069	5
	56	277991	1089	722009	285947	1130	714053	7956	41	2044	79 4
10	57	278644	1087	721356	286624	1128	713376	7980	41	2020	3
	58	279297	1086	720703	287301	1126	712699	8004	41	1996	2
	59	279948	1084	720052	287977	1125	712023	8029	41	1971	1
11	0	280599	1082	719401	288652	1123	711348	8053	41	1947	**79** 0
	1	281248	1081	718752	289326	1122	710674	8078	41	1922	59
	2	281897	1079	718103	289999	1120	710001	8103	41	1897	58
	3	282544	1077	717456	290671	1118	709329	8127	41	1873	57
	4	283190	1076	716810	291342	1117	708658	8152	41	1848	56
	5	283836	1074	716164	292013	1115	707987	8177	41	1823	78 55
11	6	284480	1072	715520	292682	1114	707318	8201	41	1799	54
	7	285124	1071	714876	293350	1112	706650	8226	42	1774	53
	8	285766	1069	714234	294017	1111	705983	8251	42	1749	52
	9	286408	1067	713592	294684	1109	705316	8276	42	1724	51
	10	287048	1066	712952	295349	1107	704651	8301	42	1699	50
	11	287687	1064	712313	296013	1106	703987	8326	42	1674	49
	12	288326	1063	711674	296677	1104	703323	8351	42	1649	48
	13	288964	1061	711036	297339	1103	702661	8376	42	1624	47
	14	289600	1059	710400	298001	1101	701999	8401	42	1599	46
	15	290236		709764	298662		701338	8426		1574	**78** 45
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
79½ Deg.											78¾ Deg.

11¼ Deg.		TABLE V.—Log. Sines, etc.								12 Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·00		9·99	
11	15	290236	1058	709764	298662	1100	701338	8426	42	1574	45
	16	290870	1056	709130	299322	1098	700678	8451	42	1549	44
	17	291504	1054	708496	299980	1096	700020	8476	42	1524	43
	18	292137	1053	707863	300638	1095	699362	8502	42	1498	42
	19	292768	1051	707232	301295	1093	698705	8527	42	1473	41
	20	293399	1050	706601	301951	1092	698049	8552	42	1448	40
	21	294029	1048	705971	302607	1090	697393	8578	42	1422	39
	22	294658	1046	705342	303261	1089	696739	8603	42	1397	38
	23	295286	1045	704714	303914	1087	696086	8628	43	1372	78 37
11	24	295913	1043	704087	304567	1086	695433	8654	43	1346	36
	25	296539	1042	703461	305218	1084	694782	8679	43	1321	35
	26	297164	1040	702836	305869	1083	694131	8705	43	1295	34
	27	297788	1039	702212	306519	1081	693481	8730	43	1270	33
	28	298412	1037	701588	307168	1080	692832	8756	43	1244	32
	29	299034	1036	700966	307815	1078	692185	8782	43	1218	31
	30	299655	1034	700345	308463	1077	691537	8807	43	1193	30
	31	300276	1032	699724	309109	1075	690891	8833	43	1167	29
	32	300895	1031	699105	309754	1074	690246	8859	43	1141	78 28
11	33	301514	1029	698486	310398	1073	689602	8885	43	1115	27
	34	302132	1028	697868	311042	1071	688958	8910	43	1090	26
	35	302748	1026	697252	311685	1070	688315	8936	43	1064	25
	36	303364	1025	696636	312327	1068	687673	8962	43	1038	24
	37	303979	1023	696021	312967	1067	687033	8988	43	1012	23
	38	304593	1022	695407	313608	1065	686392	9014	43	0986	22
	39	305207	1020	694793	314247	1064	685753	9040	43	0960	21
	40	305819	1019	694181	314885	1062	685115	9066	43	0934	20
	41	306430	1017	693570	315523	1061	684477	9092	44	0908	78 19
11	42	307041	1016	692959	316159	1060	683841	9118	44	0882	18
	43	307650	1014	692350	316795	1058	683205	9145	44	0855	17
	44	308259	1013	691741	317430	1057	682570	9171	44	0829	16
	45	308867	1011	691133	318064	1055	681936	9197	44	0803	15
	46	309474	1010	690526	318697	1054	681303	9223	44	0777	14
	47	310080	1008	689920	319329	1053	680671	9250	44	0750	13
	48	310685	1007	689315	319961	1051	680039	9276	44	0724	12
	49	311289	1005	688711	320592	1050	679408	9303	44	0697	11
	50	311893	1004	688107	321222	1048	678778	9329	44	0671	78 10
11	51	312495	1003	687505	321851	1047	678149	9356	44	0644	9
	52	313097	1001	686903	322479	1045	677521	9382	44	0618	8
	53	313698	1000	686302	323106	1044	676894	9409	44	0591	7
	54	314297	998	685703	323733	1043	676267	9435	44	0565	6
	55	314897	997	685103	324358	1041	675642	9462	44	0538	5
	56	315495	996	684505	324983	1040	675017	9489	44	0511	4
	57	316092	994	683908	325607	1039	674393	9515	45	0485	3
	58	316689	993	683311	326231	1037	673769	9542	45	0458	2
	59	317284	991	682716	326853	1036	673147	9569	45	0431	1
	60	317879		682121	327475		672525	9596	45	0404	78 0
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
78¾ Deg.											78 Deg.

12 Deg.		TABLE V.—Log. Sines, etc.									12¾ Deg.
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·3		10·6	9·		10·	10·0		9·9	
12	0	17879		82121	327474		672526	09596		90404	60
	1	18473	990	81527	328095	1035	671905	09622	45	90378	59
	2	19066	988	80934	328715	1033	671285	09649	45	90351	58
	3	19658	987	80344	329334	1032	670666	09676	45	90324	57
	4	20249	986	79751	329953	1030	670047	09703	45	90297	56
	5	20840	984	79160	330570	1029	669430	09730	45	90270	55
	6	21430	983	78570	331187	1028	668813	09757	45	90243	54
	7	22019	982	77981	331803	1026	668197	09785	45	90215	53
	8	22607	980	77393	332418	1025	667582	09812	45	90188	77 52
			979			1024			45		
12	9	23194		76806	333033		666967	09839		90161	51
	10	23780	977	76220	333646	1023	666354	09866	45	90134	50
	11	24366	976	75634	334259	1021	665741	09893	45	90107	49
	12	24950	975	75050	334871	1020	665129	09921	46	90079	48
	13	25534	973	74466	335482	1019	664518	09948	46	90052	47
	14	26117	972	73883	336093	1017	663907	09975	46	90025	46
	15	26700	970	73300	336702	1016	663298	10003	46	89997	45
	16	27281	969	72719	337311	1015	662689	10030	46	89970	44
	17	27862	968	72138	337919	1013	662081	10058	46	89942	77 43
			966			1012			46		
12	18	28442		71558	338527		661473	10085		89915	42
	19	29021	965	70979	339133	1011	660867	10113	46	89887	41
	20	29599	964	70401	339739	1010	660261	10140	46	89860	40
	21	30176	962	69824	340344	1008	659656	10168	46	89832	39
	22	30753	961	69247	340948	1007	659052	10196	46	89804	38
	23	31329	960	68671	341552	1006	658448	10223	46	89777	37
	24	31903	958	68097	342155	1004	657845	10251	46	89749	36
	25	32478	957	67522	342757	1003	657243	10279	47	89721	35
	26	33051	956	66949	343358	1002	656642	10307	47	89693	77 34
			954			1000			47		
12	27	33624		66376	343958		656042	10335		89665	33
	28	34195	953	65805	344558	999	655442	10363	47	89637	32
	29	34766	952	65234	345157	998	654843	10391	47	89609	31
	30	35337	950	64663	345755	997	654245	10418	47	89582	30
	31	35906	949	64094	346353	996	653647	10447	47	89553	29
	32	36475	948	63525	346949	994	653051	10475	47	89525	28
	33	37043	946	62957	347545	993	652455	10503	47	89497	27
	34	37610	945	62390	348141	992	651859	10531	47	89469	26
	35	38176	944	61824	348735	991	651265	10559	47	89441	77 25
			943			990			47		
12	36	38742		61258	349329		650671	10587		89413	24
	37	39306	941	60694	349922	988	650078	10616	47	89384	23
	38	39871	940	60129	350514	987	649486	10644	47	89356	22
	39	40434	939	59566	351106	986	648894	10672	47	89328	21
	40	40996	937	59004	351697	985	648303	10700	47	89300	20
	41	41558	936	58442	352287	983	647713	10729	47	89271	19
	42	42119	935	57881	352876	982	647124	10757	47	89243	18
	43	42679	934	57321	353465	981	646535	10786	47	89214	17
	44	43239	932	56761	354053	980	645947	10814	47	89186	16
	45	43797	931	56203	354640	979	645360	10843	47	89157	77 15
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
78 Deg.											77¼ Deg.

12¾ Deg.		TABLE V.—Log. Sines, etc.								13¼ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·01		9·98	
12	45	343797	930	656203	354640	977	645360	0843	47	9157	15
	46	344355	929	655645	355227	976	644773	0872	48	9128	14
	47	344912	927	655088	355813	975	644187	0900	48	9100	13
	48	345469	926	654531	356398	974	643602	0929	48	9071	12
	49	346024	925	653976	356982	973	643018	0958	48	9042	11
	50	346579	924	653421	357566	971	642434	0986	48	9014	10
	51	347134	922	652866	358149	970	641851	1015	48	8985	9
	52	347687	921	652313	358731	969	641269	1044	48	8956	8
	53	348240	920	651760	359313	968	640687	1073	48	8927	77 7
12	54	348792	919	651208	359893	967	640107	1102	48	8898	6
	55	349343	917	650657	360474	966	639526	1131	48	8869	5
	56	349893	916	650107	361053	965	638947	1160	48	8840	4
	57	350443	915	649557	361632	963	638368	1189	49	8811	3
	58	350992	914	649008	362210	962	637790	1218	49	8782	2
	59	351540	913	648460	362787	961	637213	1247	49	8753	1
13	0	352088	911	647912	363364	960	636636	1276	49	8724	**77** 0
	1	352635	910	647365	363940	959	636060	1305	49	8695	59
	2	353181	909	646819	364515	958	635485	1334	49	8666	76 58
13	3	353726	908	646274	365090	957	634910	1364	49	8636	57
	4	354271	907	645729	365664	955	634336	1393	49	8607	56
	5	354815	905	645185	366237	954	633763	1422	49	8578	55
	6	355358	904	644642	366810	953	633190	1452	49	8548	54
	7	355901	903	644099	367382	952	632618	1481	49	8519	53
	8	356443	902	643557	367953	951	632047	1511	49	8489	52
	9	356984	901	643016	368524	950	631476	1540	49	8460	51
	10	357524	899	642476	369094	949	630906	1570	49	8430	50
	11	358064	898	641936	369663	948	630337	1599	49	8401	76 49
13	12	358603	897	641397	370232	946	629768	1629	49	8371	48
	13	359141	896	640859	370799	945	629201	1658	49	8342	47
	14	359678	895	640322	371367	944	628633	1688	50	8312	46
	15	360215	893	639785	371933	943	628067	1718	50	8282	45
	16	360752	892	639248	372499	942	627501	1748	50	8252	44
	17	361287	891	638713	373064	941	626936	1777	50	8223	43
	18	361822	890	638178	373629	940	626371	1807	50	8193	42
	19	362356	889	637644	374193	939	625807	1837	50	8163	41
	20	362889	888	637111	374756	938	625244	1867	50	8133	76 40
13	21	363422	887	636578	375319	937	624681	1897	50	8103	39
	22	363954	885	636046	375881	935	624119	1927	50	8073	38
	23	364485	884	635515	376442	934	623558	1957	50	8043	37
	24	365016	883	634984	377003	933	622997	1987	50	8013	36
	25	365546	882	634454	377563	932	622437	2017	50	7983	35
	26	366075	881	633925	378122	931	621878	2047	50	7953	34
	27	366604	880	633396	378681	930	621319	2078	50	7922	33
	28	367131	879	632869	379239	929	620761	2108	50	7892	32
	29	367659	877	632341	379797	928	620203	2138	50	7862	31
	30	368185		631815	380354		619646	2168	50	7832	**76** 30
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
77¼ Deg.											76¾ Deg.

13½ Deg.		TABLE V.—Log. Sines, etc.								14¼ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·01		9·98	
13	30	368185	876	631815	380354	927	619646	2168	51	7832	30
	31	368711	875	631289	380910	926	619090	2199	51	7801	29
	32	369236	874	630764	381466	925	618534	2229	51	7771	28
	33	369761	873	630239	382020	924	617980	2260	51	7740	27
	34	370285	872	629715	382575	923	617425	2290	51	7710	26
	35	370808	871	629192	383129	922	616871	2321	51	7679	25
	36	371330	870	628670	383682	921	616318	2351	51	7649	24
	37	371852	869	628148	384234	920	615766	2382	51	7618	23
	38	372373	867	627627	384786	919	615214	2412	51	7588	76 22
13	39	372894	866	627106	385337	918	614663	2443	51	7557	21
	40	373414	865	626586	385888	917	614112	2474	51	7526	20
	41	373933	864	626067	386438	915	613562	2504	51	7496	19
	42	374452	863	625548	386987	914	613013	2535	51	7465	18
	43	374970	862	625030	387536	913	612464	2566	51	7434	17
	44	375487	861	624513	388084	912	611916	2597	51	7403	16
	45	376003	860	623997	388631	911	611369	2628	52	7372	15
	46	376519	859	623481	389178	910	610822	2659	52	7341	14
	47	377035	858	622965	389724	909	610276	2690	52	7310	76 13
13	48	377549	857	622451	390270	908	609730	2721	52	7279	12
	49	378063	856	621937	390815	907	609185	2752	52	7248	11
	50	378577	854	621423	391360	906	608640	2783	52	7217	10
	51	379089	853	620911	391903	905	608097	2814	52	7186	9
	52	379601	852	620399	392447	904	607553	2845	52	7155	8
	53	380113	851	619887	392989	903	607011	2876	52	7124	7
	54	380624	850	619376	393531	902	606469	2908	52	7092	6
	55	381134	849	618866	394073	901	605927	2939	52	7061	5
	56	381643	848	618357	394614	900	605386	2970	52	7030	76 4
13	57	382152	847	617848	395154	899	604846	3002	52	6998	3
	58	382661	846	617339	395694	898	604306	3033	52	6967	2
	59	383168	845	616832	396233	897	603767	3064	52	6936	1
14	0	383675	844	616325	396771	896	603229	3096	52	6904	**76** 0
	1	384182	843	615818	397309	896	602691	3127	52	6873	59
	2	384687	842	615313	397846	895	602154	3159	53	6841	58
	3	385192	841	614808	398383	894	601617	3191	53	6809	57
	4	385697	840	614303	398919	893	601081	3222	53	6778	56
	5	386201	839	613799	399455	892	600545	3254	53	6746	75 55
14	6	386704	838	613296	399990	891	600010	3286	53	6714	54
	7	387207	837	612793	400524	890	599476	3317	53	6683	53
	8	387709	836	612291	401058	889	598942	3349	53	6651	52
	9	388210	835	611790	401591	888	598409	3381	53	6619	51
	10	388711	834	611289	402124	887	597876	3413	53	6587	50
	11	389211	833	610789	402656	886	597344	3445	53	6555	49
	12	389711	832	610289	403187	885	596813	3477	53	6523	48
	13	390210	831	609790	403718	884	596282	3509	53	6491	47
	14	390708	830	609292	404249	883	595751	3541	53	6459	46
	15	391206		608794	404778		595222	3573	53	6427	**75** 45
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
76½ Deg.											75¾ Deg.

14¼ Deg.		TABLE V.—Log. Sines, etc.								15 Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·01		9·98	
14	15	391206	828	608794	404778	882	595222	3573	53	6427	45
	16	391703	827	608297	405308	881	594692	3605	53	6395	44
	17	392199	826	607801	405836	880	594164	3637	54	6363	43
	18	392695	825	607305	406364	879	593636	3669	54	6331	42
	19	393191	824	606809	406892	878	593108	3701	54	6299	41
	20	393685	823	606315	407419	877	592581	3734	54	6266	40
	21	394179	822	605821	407945	876	592055	3766	54	6234	39
	22	394673	821	605327	408471	875	591529	3798	54	6202	38
	23	395166	820	604834	408997	874	591003	3831	54	6169	75 37
14	24	395658	819	604342	409521	874	590479	3863	54	6137	36
	25	396150	818	603850	410045	873	589955	3896	54	6104	35
	26	396641	817	603359	410569	872	589431	3928	54	6072	34
	27	397132	817	602868	411092	871	588908	3961	54	6039	33
	28	397621	816	602379	411615	870	588385	3993	54	6007	32
	29	398111	815	601889	412137	869	587863	4026	54	5974	31
	30	398600	814	601400	412658	868	587342	4058	54	5942	30
	31	399088	813	600912	413179	867	586821	4091	54	5909	29
	32	399575	812	600425	413699	866	586301	4124	55	5876	75 28
14	33	400062	811	599938	414219	865	585781	4157	55	5843	27
	34	400549	810	599451	414738	864	585262	4189	55	5811	26
	35	401035	809	598965	415257	864	584743	4222	55	5778	25
	36	401520	808	598480	415775	863	584225	4255	55	5745	24
	37	402005	807	597995	416293	862	583707	4288	55	5712	23
	38	402489	806	597511	416810	861	583190	4321	55	5679	22
	39	402972	805	597028	417326	860	582674	4354	55	5646	21
	40	403455	804	596545	417842	859	582158	4387	55	5613	20
	41	403938	803	596062	418358	858	581642	4420	55	5580	75 19
14	42	404420	802	595580	418873	857	581127	4453	55	5547	18
	43	404901	801	595099	419387	856	580613	4486	55	5514	17
	44	405382	800	594618	419901	855	580099	4520	55	5480	16
	45	405862	799	594138	420415	855	579585	4553	55	5447	15
	46	406341	798	593659	420927	854	579073	4586	56	5414	14
	47	406820	797	593180	421440	853	578560	4620	56	5380	13
	48	407299	796	592701	421952	852	578048	4653	56	5347	12
	49	407777	795	592223	422463	851	577537	4686	56	5314	11
	50	408254	794	591746	422974	850	577026	4720	56	5280	75 10
14	51	408731	794	591269	423484	849	576516	4753	56	5247	9
	52	409207	793	590793	423993	848	576007	4787	56	5213	8
	53	409682	792	590318	424503	848	575497	4820	56	5180	7
	54	410157	791	589843	425011	847	574989	4854	56	5146	6
	55	410632	790	589368	425519	846	574481	4887	56	5113	5
	56	411106	789	588894	426027	845	573973	4921	56	5079	4
	57	411579	788	588421	426534	844	573466	4955	56	5045	3
	58	412052	787	587948	427041	843	572959	4989	56	5011	2
	59	412524	786	587476	427547	843	572453	5022	56	4978	1
	60	412996		587004	428052		571948	5056		4944	**75** 0
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
75¾ Deg.											75 Deg.

15 Deg.		TABLE V.—Log. Sines, etc.									15¾ Deg
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·01		9·98	
15	0	412996	785	587004	428052	842	571948	5056	57	4944	60
	1	413467	784	586533	428557	841	571443	5090	57	4910	59
	2	413938	783	586062	429062	840	570938	5124	57	4876	58
	3	414408	783	585592	429566	839	570434	5158	57	4842	57
	4	414878	782	585122	430070	838	569930	5192	57	4808	56
	5	415347	781	584653	430573	838	569427	5226	57	4774	55
	6	415815	780	584185	431075	837	568925	5260	57	4740	54
	7	416283	779	583717	431577	836	568423	5294	57	4706	53
	8	416751	778	583249	432079	835	567921	5328	57	4672	74 52
15	9	417217	777	582783	432580	834	567420	5363	57	4637	51
	10	417684	776	582316	433080	833	566920	5397	57	4603	50
	11	418150	775	581850	433580	832	566420	5431	57	4569	49
	12	418615	774	581385	434080	832	565920	5465	57	4535	48
	13	419079	773	580921	434579	831	565421	5500	57	4500	47
	14	419544	773	580456	435078	830	564922	5534	57	4466	46
	15	420007	772	579993	435576	829	564424	5568	57	4432	45
	16	420470	771	579530	436073	828	563927	5603	58	4397	44
	17	420933	770	579067	436570	828	563430	5637	58	4363	74 43
15	18	421395	769	578605	437067	827	562933	5672	58	4328	42
	19	421857	768	578143	437563	826	562437	5706	58	4294	41
	20	422318	767	577682	438059	825	561941	5741	58	4259	40
	21	422778	767	577222	438554	824	561446	5776	58	4224	39
	22	423238	766	576762	439048	823	560952	5810	58	4190	38
	23	423697	765	576303	439543	823	560457	5845	58	4155	37
	24	424156	764	575844	440036	822	559964	5880	58	4120	36
	25	424615	763	575385	440529	821	559471	5915	58	4085	35
	26	425073	762	574927	441022	820	558978	5950	58	4050	74 34
15	27	425530	761	574470	441514	819	558486	5985	58	4015	33
	28	425987	760	574013	442006	819	557994	6019	58	3981	32
	29	426443	760	573557	442497	818	557503	6054	58	3946	31
	30	426899	759	573101	442988	817	557012	6089	58	3911	30
	31	427354	758	572646	443479	816	556521	6125	58	3875	29
	32	427809	757	572191	443968	816	556032	6160	58	3840	28
	33	428263	756	571737	444458	815	555542	6195	59	3805	27
	34	428717	755	571283	444947	814	555053	6230	59	3770	26
	35	429170	754	570830	445435	813	554565	6265	59	3735	74 25
15	36	429623	753	570377	445923	812	554077	6300	59	3700	24
	37	430075	752	569925	446411	812	553589	6336	59	3664	23
	38	430527	752	569473	446898	811	553102	6371	59	3629	22
	39	430978	751	569022	447384	810	552616	6406	59	3594	21
	40	431429	750	568571	447870	809	552130	6442	59	3558	20
	41	431879	749	568121	448356	809	551644	6477	59	3523	19
	42	432329	749	567671	448841	808	551159	6513	59	3487	18
	43	432778	748	567222	449326	807	550674	6548	59	3452	17
	44	433226	747	566774	449810	806	550190	6584	59	3416	16
	45	433675		566325	450294		549706	6619	59	3381	**74** 15
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
75 Deg.											74¼ Deg.

15¾ Deg.		TABLE V.—Log. Sines, etc.									16¼ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.		
		9·		10·	9·		10·	10·01		9·98		
15	45	433675	746	566325	450294	806	549706	6619	59	3381		15
	46	434122	745	565878	450777	805	549223	6655	59	3345		14
	47	434569	744	565431	451260	804	548740	6691	59	3309		13
	48	435016	744	564984	451743	803	548257	6727	60	3273		12
	49	435462	743	564538	452225	802	547775	6762	60	3238		11
	50	435908	742	564092	452706	802	547294	6798	60	3202		10
	51	436353	741	563647	453187	801	546813	6834	60	3166		9
	52	436798	740	563202	453668	800	546332	6870	60	3130		8
	53	437242	740	562758	454148	799	545852	6906	60	3094	74	7
15	54	437686	739	562314	454628	799	545372	6942	60	3058		6
	55	438129	738	561871	455107	798	544893	6978	60	3022		5
	56	438572	737	561428	455586	797	544414	7014	60	2986		4
	57	439014	736	560986	456064	796	543936	7050	60	2950		3
	58	439456	736	560544	456542	796	543458	7086	60	2914		2
	59	439897	735	560103	457019	795	542981	7122	60	2878		1
16	0	440338	734	559662	457496	794	542504	7158	60	2842	**74**	0
	1	440778	733	559222	457973	793	542027	7195	60	2805		59
	2	441218	732	558782	458449	793	541551	7231	61	2769	73	58
16	3	441658	731	558342	458925	792	541075	7267	61	2733		57
	4	442096	731	557904	459400	791	540600	7304	61	2696		56
	5	442535	730	557465	459875	790	540125	7340	61	2660		55
	6	442973	729	557027	460349	790	539651	7376	61	2624		54
	7	443410	728	556590	460823	789	539177	7413	61	2587		53
	8	443847	727	556153	461297	788	538703	7449	61	2551		52
	9	444284	727	555716	461770	788	538230	7486	61	2514		51
	10	444720	726	555280	462242	787	537758	7523	61	2477		50
	11	445155	725	554845	462714	786	537286	7559	61	2441	73	49
16	12	445590	724	554410	463186	785	536814	7596	61	2404		48
	13	446025	723	553975	463658	785	536342	7633	61	2367		47
	14	446459	723	553541	464129	784	535871	7669	61	2331		46
	15	446893	722	553107	464599	783	535401	7706	61	2294		45
	16	447326	721	552674	465069	783	534931	7743	61	2257		44
	17	447759	720	552241	465539	782	534461	7780	62	2220		43
	18	448191	720	551809	466008	781	533992	7817	62	2183		42
	19	448623	719	551377	466476	780	533524	7854	62	2146		41
	20	449054	718	550946	466945	780	533055	7891	62	2109	73	40
16	21	449485	717	550515	467413	779	532587	7928	62	2072		39
	22	449915	716	550085	467880	778	532120	7965	62	2035		38
	23	450345	716	549655	468347	778	531653	8002	62	1998		37
	24	450775	715	549225	468814	777	531186	8039	62	1961		36
	25	451204	714	548796	469280	776	530720	8076	62	1924		35
	26	451632	713	548368	469746	775	530254	8114	62	1886		34
	27	452060	713	547940	470211	775	529789	8151	62	1849		33
	28	452488	712	547512	470676	774	529324	8188	62	1812		32
	29	452915	711	547085	471141	773	528859	8226	62	1774		31
	30	453342		546658	471605		528395	8263		1737	**73**	30
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	°	′
74¼ Deg.											73¼ Deg.	

16½ Deg.		TABLE V.—Log. Sines, etc.								17¼ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·01		9·98	
16	30	453342	710	546658	471605	773	528395	8263	62	1737	30
	31	453768	710	546232	472068	772	527932	8301	63	1699	29
	32	454194	709	545806	472532	771	527468	8338	63	1662	28
	33	454619	708	545381	472995	771	527005	8375	63	1625	27
	34	455044	707	544956	473457	770	526543	8413	63	1587	26
	35	455469	707	544531	473919	769	526081	8451	63	1549	25
	36	455893	706	544107	474381	769	525619	8488	63	1512	24
	37	456316	705	543684	474842	768	525158	8526	63	1474	23
	38	456739	704	543261	475303	767	524697	8564	63	1436	73 22
16	39	457162	704	542838	475763	767	524237	8601	63	1399	21
	40	457584	703	542416	476223	766	523777	8639	63	1361	20
	41	458006	702	541994	476683	765	523317	8677	63	1323	19
	42	458427	701	541573	477142	765	522858	8715	63	1285	18
	43	458848	701	541152	477601	764	522399	8753	63	1247	17
	44	459268	700	540732	478059	763	521941	8791	63	1209	16
	45	459688	699	540312	478517	763	521483	8829	63	1171	15
	46	460108	698	539892	478975	762	521025	8867	64	1133	14
	47	460527	698	539473	479432	761	520568	8905	64	1095	73 13
16	48	460946	697	539054	479889	761	520111	8943	64	1057	12
	49	461364	696	538636	480345	760	519655	8981	64	1019	11
	50	461782	695	538218	480801	759	519199	9019	64	0981	10
	51	462199	695	537801	481257	759	518743	9058	64	0942	9
	52	462616	694	537384	481712	758	518288	9096	64	0904	8
	53	463032	693	536968	482167	757	517833	9134	64	0866	7
	54	463448	693	536552	482621	757	517379	9173	64	0827	6
	55	463864	692	536136	483075	756	516925	9211	64	0789	5
	56	464279	691	535721	483529	755	516471	9250	64	0750	73 4
16	57	464694	690	535306	483982	755	516018	9288	64	0712	3
	58	465108	690	534892	484435	754	515565	9327	64	0673	2
	59	465522	689	534478	484887	753	515113	9365	64	0635	1
17	0	465935	688	534065	485339	753	514661	9404	64	0596	**73** 0
	1	466348	688	533652	485791	752	514209	9442	64	0558	59
	2	466761	687	533239	486242	751	513758	9481	65	0519	58
	3	467173	686	532827	486693	751	513307	9520	65	0480	57
	4	467585	685	532415	487143	750	512857	9558	65	0442	56
	5	467996	685	532004	487593	749	512407	9597	65	0403	72 55
17	6	468407	684	531593	488043	749	511957	9636	65	0364	54
	7	468817	683	531183	488492	748	511508	9675	65	0325	53
	8	469227	683	530773	488941	747	511059	9714	65	0286	52
	9	469637	682	530363	489390	747	510610	9753	65	0247	51
	10	470046	681	529954	489838	746	510162	9792	65	0208	50
	11	470455	680	529545	490286	746	509714	9831	65	0169	49
	12	470863	680	529137	490733	745	509267	9870	65	0130	48
	13	471271	679	528729	491180	744	508820	9909	65	0091	47
	14	471679	678	528321	491627	744	508373	9948	65	0052	46
	15	472086		527914	492073		507927	9988		0012	**72** 45
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
73½ Deg.											72¾ Deg.

17¼ Deg.		TABLE V.—Log Sines, etc.								18 Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·4		10·5	9·		10·	10·0		9·9	
17	15	72086	678	27914	492073	743	507927	19988	65	80012	45
	16	72492	677	27508	492519	743	507481	20027	65	79973	44
	17	72898	676	27102	492965	742	507035	20066	66	79934	43
	18	73304	676	26696	493410	741	506590	20105	66	79895	42
	19	73710	675	26290	493854	740	506146	20145	66	79855	41
	20	74115	674	25885	494299	740	505701	20184	66	79816	40
	21	74519	674	25481	494743	740	505257	20224	66	79776	39
	22	74923	673	25077	495186	739	504814	20263	66	79737	38
	23	75327	672	24673	495630	738	504370	20303	66	79697	72 37
17	24	75730	672	24270	496073	737	503927	20342	66	79658	36
	25	76133	671	23867	496515	737	503485	20382	66	79618	35
	26	76536	670	23464	496975	736	503043	20421	66	79579	34
	27	76938	669	23062	497399	736	502601	20461	66	79539	33
	28	77340	669	22660	497841	735	502159	20501	66	79499	32
	29	77741	668	22259	498282	734	501718	20541	66	79459	31
	30	78142	667	21858	498722	734	501278	20580	66	79420	30
	31	78542	667	21458	499163	733	500837	20620	66	79380	29
	32	78942	666	21058	499603	733	500397	20660	66	79340	72 28
17	33	79342	665	20658	500042	732	499958	20700	67	79300	27
	34	79741	665	20259	500481	731	499519	20740	67	79260	26
	35	80140	664	19860	500920	731	499080	20780	67	79220	25
	36	80539	663	19461	501359	730	498641	20820	67	79180	24
	37	80937	663	19063	501797	730	498203	20860	67	79140	23
	38	81334	662	18666	502235	729	497765	20900	67	79100	22
	39	81731	661	18269	502672	728	497328	20941	67	79059	21
	40	82128	661	17872	503109	728	496891	20981	67	79019	20
	41	82525	660	17475	503546	727	496454	21021	67	78979	72 19
17	42	82921	659	17079	503982	727	496018	21061	67	78939	18
	43	83316	659	16684	504418	726	495582	21102	67	78898	17
	44	83712	658	16288	504854	725	495146	21142	67	78858	16
	45	84107	657	15893	505289	725	494711	21183	67	78817	15
	46	84501	657	15499	505724	724	494276	21223	67	78777	14
	47	84895	656	15105	506159	724	493841	21264	67	78736	13
	48	85289	655	14711	506593	723	493407	21304	68	78696	12
	49	85682	655	14318	507027	722	492973	21345	68	78655	11
	50	86075	654	13925	507460	722	492540	21385	68	78615	72 10
17	51	86467	653	13533	507893	721	492107	21426	68	78574	9
	52	86860	653	13140	508326	721	491674	21467	68	78533	8
	53	87251	652	12749	508759	720	491241	21507	68	78493	7
	54	87643	651	12357	509191	719	490809	21548	68	78452	6
	55	88034	651	11966	509622	719	490378	21589	68	78411	5
	56	88424	650	11576	510054	718	489946	21630	68	78370	4
	57	88814	650	11186	510485	718	489515	21671	68	78329	3
	58	89204	649	10796	510916	717	489084	21712	68	78288	2
	59	89593	648	10407	511346	716	488654	21753	68	78247	1
	60	89982		10018	511776		488224	21794		78206	**72** 0
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
72¾ Deg.											72 Deg.

18 Deg.		TABLE V.—Log. Sines, etc.									18¾ Deg.
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·02		9·97	
18	0	489982	648	510018	511776	716	488224	1794	68	8206	60
	1	490371	648	509629	512206	716	487794	1835	68	8165	59
	2	490759	647	509241	512635	715	487365	1876	68	8124	58
	3	491147	646	508853	513064	714	486936	1917	69	8083	57
	4	491535	646	508465	513493	714	486507	1958	69	8042	56
	5	491922	645	508078	513921	713	486079	1999	69	8001	55
	6	492308	644	507692	514349	713	485651	2041	69	7959	54
	7	492695	644	507305	514777	712	485223	2082	69	7918	53
	8	493081	643	506919	515204	712	484796	2123	69	7877	71 52
18	9	493466	642	506534	515631	711	484369	2165	69	7835	51
	10	493851	642	506149	516057	710	483943	2206	69	7794	50
	11	494236	641	505764	516484	710	483516	2248	69	7752	49
	12	494621	641	505379	516910	709	483090	2289	69	7711	48
	13	495005	640	504995	517335	709	482665	2331	69	7669	47
	14	495388	639	504612	517761	708	482239	2372	69	7628	46
	15	495772	639	504228	518185	708	481815	2414	69	7586	45
	16	496154	638	503846	518610	707	481390	2456	69	7544	44
	17	496537	637	503463	519034	706	480966	2497	70	7503	71 43
18	18	496919	637	503081	519458	706	480542	2539	70	7461	42
	19	497301	636	502699	519882	705	480118	2581	70	7419	41
	20	497682	636	502318	520305	705	479695	2623	70	7377	40
	21	498064	635	501936	520728	704	479272	2665	70	7335	39
	22	498444	634	501556	521151	703	478849	2707	70	7293	38
	23	498825	634	501175	521573	703	478427	2749	70	7251	37
	24	499204	633	500796	521995	703	478005	2791	70	7209	36
	25	499584	632	500416	522417	702	477583	2833	70	7167	35
	26	499963	632	500037	522838	702	477162	2875	70	7125	71 34
18	27	500342	631	499658	523259	701	476741	2917	70	7083	33
	28	500721	631	499279	523680	701	476320	2959	70	7041	32
	29	501099	630	498901	524100	700	475900	3001	70	6999	31
	30	501476	629	498524	524520	699	475480	3043	70	6957	30
	31	501854	629	498146	524939	699	475061	3086	70	6914	29
	32	502231	628	497769	525359	698	474641	3128	70	6872	28
	33	502607	628	497393	525778	698	474222	3170	71	6830	27
	34	502984	627	497016	526197	697	473803	3213	71	6787	26
	35	503360	626	496640	526615	697	473385	3255	71	6745	71 25
18	36	503735	626	496265	527033	696	472967	3298	71	6702	24
	37	504110	625	495890	527451	696	472549	3340	71	6660	23
	38	504485	625	495515	527868	695	472132	3383	71	6617	22
	39	504860	624	495140	528285	695	471715	3426	71	6574	21
	40	505234	623	494766	528702	694	471298	3468	71	6532	20
	41	505608	623	494392	529119	693	470881	3511	71	6489	19
	42	505981	622	494019	529535	693	470465	3554	71	6446	18
	43	506354	622	493646	529950	693	470050	3596	71	6404	17
	44	506727	621	493273	530366	692	469634	3639	71	6361	16
	45	507099		492901	530781		469219	3682		6318	**71** 15
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
72 Deg.											71¼ Deg.

18¾ Deg.		TABLE V.—Log. Sines, etc.									19¼ Deg.
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·02		9·97	
18	45	507099	620	492901	530781	691	469219	3682	71	6318	15
	46	507471	620	492529	531196	691	468804	3725	71	6275	14
	47	507843	619	492157	531611	690	468389	3768	72	6232	13
	48	508214	619	491786	532025	690	467975	3811	72	6189	12
	49	508585	618	491415	532439	689	467561	3854	72	6146	11
	50	508956	618	491044	532853	689	467147	3897	72	6103	10
	51	509326	617	490674	533266	688	466734	3940	72	6060	9
	52	509696	616	490304	533679	688	466321	3983	72	6017	8
	53	510065	616	489935	534092	687	465908	4026	72	5974	71 7
18	54	510434	615	489566	534504	687	465496	4070	72	5930	6
	55	510803	615	489197	534916	686	465084	4113	72	5887	5
	56	511172	614	488828	535328	686	464672	4156	72	5844	4
	57	511540	613	488460	535739	685	464261	4200	72	5800	3
	58	511907	613	488093	536150	685	463850	4243	72	5757	2
	59	512275	612	487725	536561	684	463439	4286	72	5714	1
19	0	512642	612	487358	536972	684	463028	4330	73	5670	**71** 0
	1	513009	611	486991	537382	683	462618	4373	73	5627	59
	2	513375	611	486625	537792	683	462208	4417	73	5583	70 58
19	3	513741	610	486259	538202	682	461798	4461	73	5539	57
	4	514107	609	485893	538611	682	461389	4504	73	5496	56
	5	514472	609	485528	539020	681	460980	4548	73	5452	55
	6	514837	608	485163	539429	681	460571	4592	73	5408	54
	7	515202	608	484798	539837	680	460163	4635	73	5365	53
	8	515566	607	484434	540245	680	459755	4679	73	5321	52
	9	515930	607	484070	540653	679	459347	4723	73	5277	51
	10	516294	606	483706	541061	679	458939	4767	73	5233	50
	11	516657	605	483343	541468	678	458532	4811	73	5189	70 49
19	12	517020	605	482980	541875	678	458125	4855	73	5145	48
	13	517382	604	482618	542281	677	457719	4899	73	5101	47
	14	517745	604	482255	542688	677	457312	4943	73	5057	46
	15	518107	603	481893	543094	676	456906	4987	73	5013	45
	16	518468	603	481532	543499	676	456501	5031	74	4969	44
	17	518829	602	481171	543905	675	456095	5075	74	4925	43
	18	519190	601	480810	544310	675	455690	5120	74	4880	42
	19	519551	601	480449	544715	674	455285	5164	74	4836	41
	20	519911	600	480089	545119	674	454881	5208	74	4792	70 40
19	21	520271	600	479729	545524	673	454476	5252	74	4748	39
	22	520631	599	479369	545928	673	454072	5297	74	4703	38
	23	520990	599	479010	546331	672	453669	5341	74	4659	37
	24	521349	598	478651	546735	672	453265	5386	74	4614	36
	25	521707	598	478293	547138	671	452862	5430	74	4570	35
	26	522066	597	477934	547540	671	452460	5475	74	4525	34
	27	522424	596	477576	547943	670	452057	5519	74	4481	33
	28	522781	596	477219	548345	670	451655	5564	74	4436	32
	29	523138	595	476862	548747	669	451253	5609	74	4391	31
	30	523495		476505	549149		450851	5653		4347	**70** 30
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
71¼ Deg.											70¾ Deg.

19½ Deg.	TABLE V.—Log. Sines, etc.									20¼ Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9·		10·	9·		10·	10·02		9·97	
19 30	523495	595	476505	549149	669	450851	5653	75	4347	30
31	523852	594	476148	549550	668	450450	5698	75	4302	29
32	524208	594	475792	549951	668	450049	5743	75	4257	28
33	524564	593	475436	550352	667	449648	5788	75	4212	27
34	524920	593	475080	550752	667	449248	5833	75	4167	26
35	525275	592	474725	551152	666	448848	5878	75	4122	25
36	525630	591	474370	551552	666	448448	5923	75	4077	24
37	525984	591	474016	551952	665	448048	5968	75	4032	23
38	526339	590	473661	552351	665	447649	6013	75	3987	70 22
19 39	526693	590	473307	552750	665	447250	6058	75	3942	21
40	527046	589	472954	553149	664	446851	6103	75	3897	20
41	527400	589	472600	553548	664	446452	6148	75	3852	19
42	527753	588	472247	553946	663	446054	6193	75	3807	18
43	528105	588	471895	554344	663	445656	6239	75	3761	17
44	528458	587	471542	554741	662	445259	6284	76	3716	16
45	528810	587	471190	555139	662	444861	6329	76	3671	15
46	529161	586	470839	555536	661	444464	6375	76	3625	14
47	529513	586	470487	555933	661	444067	6420	76	3580	70 13
19 48	529864	585	470136	556329	660	443671	6465	76	3535	12
49	530215	585	469785	556725	660	443275	6511	76	3489	11
50	530565	584	469435	557121	659	442879	6556	76	3444	10
51	530915	584	469085	557517	659	442483	6602	76	3398	9
52	531265	583	468735	557913	659	442087	6648	76	3352	8
53	531614	582	468386	558308	658	441692	6693	76	3307	7
54	531963	582	468037	558702	658	441298	6739	76	3261	6
55	532312	581	467688	559097	657	440903	6785	76	3215	5
56	532661	581	467339	559491	657	440509	6831	76	3169	70 4
19 57	533009	580	466991	559885	656	440115	6876	76	3124	3
58	533357	580	466643	560279	656	439721	6922	76	3078	2
59	533704	579	466296	560673	655	439327	6968	77	3032	1
20 0	534052	578	465948	561066	655	438934	7014	77	2986	**70** 0
1	534399	577	465601	561459	654	438541	7060	77	2940	59
2	534745	577	465255	561851	654	438149	7106	77	2894	58
3	535092	577	464908	562244	653	437756	7152	77	2848	57
4	535438	576	464562	562636	653	437364	7198	77	2802	56
5	535783	576	464217	563028	653	436972	7245	77	2755	69 55
20 6	536129	575	463871	563419	652	436581	7291	77	2709	54
7	536474	574	463526	563811	652	436189	7337	77	2663	53
8	536818	574	463182	564202	651	435798	7383	77	2617	52
9	537163	573	462837	564592	651	435408	7430	77	2570	51
10	537507	573	462493	564983	650	435017	7476	77	2524	50
11	537851	572	462149	565373	650	434627	7522	77	2478	49
12	538194	572	461806	565763	649	434237	7569	78	2431	48
13	538538	571	461462	566153	649	433847	7615	78	2385	47
14	538880	571	461120	566542	649	433458	7662	78	2338	46
15	539223		460777	566932		433068	7709		2291	**69** 45
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
70½ Deg.										69¾ Deg.

20¼ Deg.	TABLE V.—Log. Sines, etc.									21 Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9·		10·	9·		10·	10·02		9·97	
20 15	539223	570	460777	566932	648	433068	7709	78	2291	45
16	539565	570	460435	567320	648	432680	7755	78	2245	44
17	539907	569	460093	567709	647	432291	7802	78	2198	43
18	540249	569	459751	568098	647	431902	7849	78	2151	42
19	540590	568	459410	568486	646	431514	7895	78	2105	41
20	540931	568	459069	568873	646	431127	7942	78	2058	40
21	541272	567	458728	569261	645	430739	7989	78	2011	39
22	541613	567	458387	569648	645	430352	8036	78	1964	38
23	541953	566	458047	570035	645	429965	8083	78	1917	69 37
20 24	542293	566	457707	570422	644	429578	8130	78	1870	36
25	542632	565	457368	570809	644	429191	8177	78	1823	35
26	542971	565	457029	571195	643	428805	8224	78	1776	34
27	543310	564	456690	571581	643	428419	8271	79	1729	33
28	543649	564	456351	571967	642	428033	8318	79	1682	32
29	543987	563	456013	572352	642	427648	8365	79	1635	31
30	544325	563	455675	572738	642	427262	8412	79	1588	30
31	544663	562	455337	573123	641	426877	8460	79	1540	29
32	545000	562	455000	573507	641	426493	8507	79	1493	69 28
20 33	545338	561	454662	573892	640	426108	8554	79	1446	27
34	545674	561	454326	574276	640	425724	8602	79	1398	26
35	546011	560	453989	574660	639	425340	8649	79	1351	25
36	546347	560	453653	575044	639	424956	8697	79	1303	24
37	546683	559	453317	575427	639	424573	8744	79	1256	23
38	547019	559	452981	575810	638	424190	8792	79	1208	22
39	547354	558	452646	576193	638	423807	8839	79	1161	21
40	547689	558	452311	576576	637	423424	8887	79	1113	20
41	548024	557	451976	576958	637	423042	8934	80	1066	69 19
20 42	548359	557	451641	577341	636	422659	8982	80	1018	18
43	548693	556	451307	577723	636	422277	9030	80	0970	17
44	549027	556	450973	578104	636	421896	9078	80	0922	16
45	549360	555	450640	578486	635	421514	9126	80	0874	15
46	549693	555	450307	578867	635	421133	9173	80	0827	14
47	550026	554	449974	579248	634	420752	9221	80	0779	13
48	550359	554	449641	579629	634	420371	9269	80	0731	12
49	550692	553	449308	580009	634	419991	9317	80	0683	11
50	551024	553	448976	580389	633	419611	9365	80	0635	69 10
20 51	551356	552	448644	580769	633	419231	9414	80	0586	9
52	551687	552	448313	581149	632	418851	9462	80	0538	8
53	552018	552	447982	581528	632	418472	9510	80	0490	7
54	552349	551	447651	581907	632	418093	9558	80	0442	6
55	552680	551	447320	582286	631	417714	9606	80	0394	5
56	553010	550	446990	582665	631	417335	9655	81	0345	4
57	553341	550	446659	583043	630	416957	9703	81	0297	3
58	553670	549	446330	583422	630	416578	9751	81	0249	2
59	554000	549	446000	583800	629	416200	9800	81	0200	1
60	554329		445671	584177		415823	9848		0152	**69** 0
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
69¾ Deg.										69 Deg.

21 Deg.	TABLE V.—Log. Sines, etc.									21¾ Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9·5		10·4	9·		10·	10·0		9·9	
21 0	54329	548	45671	584177	629	415823	29848	81	70152	60
1	54658	548	45342	584555	629	415445	29897	81	70103	59
2	54987	547	45013	584932	628	415068	29945	81	70055	58
3	55315	547	44685	585309	628	414691	29994	81	70006	57
4	55643	546	44357	585686	627	414314	30043	81	69957	56
5	55971	546	44029	586062	627	413938	30091	81	69909	55
6	56299	545	43701	586439	627	413561	30140	81	69860	54
7	56626	545	43374	586815	626	413185	30189	81	69811	53
8	56953	544	43047	587190	626	412810	30238	81	69762	68 52
21 9	57280	544	42720	587566	625	412434	30286	81	69714	51
10	57606	543	42394	587941	625	412059	30335	81	69665	50
11	57932	543	42068	588316	625	411684	30384	82	69616	49
12	58258	543	41742	588691	624	411309	30433	82	69567	48
13	58583	542	41417	589066	624	410934	30482	82	69518	47
14	58909	542	41091	589440	623	410560	30531	82	69469	46
15	59234	541	40766	589814	623	410186	30580	82	69420	45
16	59558	541	40442	590188	623	409812	30630	82	69370	44
17	59883	540	40117	590562	622	409438	30679	82	69321	68 43
21 18	60207	540	39793	590935	622	409065	30728	82	69272	42
19	60531	539	39469	591308	622	408692	30777	82	69223	41
20	60855	539	39145	591681	621	408319	30827	82	69173	40
21	61178	538	38822	592054	621	407946	30876	82	69124	39
22	61501	538	38499	592426	620	407574	30925	82	69075	38
23	61824	537	38176	592798	620	407202	30975	82	69025	37
24	62146	537	37854	593171	619	406829	31024	82	68976	36
25	62468	536	37532	593542	619	406458	31074	83	68926	35
26	62790	536	37210	593914	618	406086	31123	83	68877	68 34
21 27	63112	536	36888	594285	618	405715	31173	83	68827	33
28	63433	535	36567	594656	618	495344	31223	83	68777	32
29	63755	535	36245	595027	617	404973	31272	83	68728	31
30	64075	534	35925	595398	617	404602	31322	83	68678	30
31	64396	534	35604	595768	617	404232	31372	83	68628	29
32	64716	533	35284	596138	616	403862	31422	83	68578	28
33	65036	533	34964	596508	616	403492	31472	83	68528	27
34	65356	532	34644	596878	616	403122	31521	83	68479	26
35	65676	532	34324	597247	615	402753	31571	83	68429	68 25
21 36	65995	531	34005	597616	615	402384	31621	83	68379	24
37	66314	531	33686	597985	615	402015	31671	83	68329	23
38	66632	531	33368	598354	614	401646	31722	83	68278	22
39	66951	530	33049	598722	614	401278	31772	84	68228	21
40	67269	530	32731	599091	613	400909	31822	84	68178	20
41	67587	529	32413	599459	613	400541	31872	84	68128	19
42	67904	529	32096	599827	613	400173	31922	84	68078	18
43	68222	528	31778	600194	612	399806	31973	84	68027	17
44	68539	528	31461	600562	612	399438	32023	84	97977	16
45	68856		31144	600929		399071	32073		67927	**68** 15
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
69 Deg.										68¼ Deg.

21¾ Deg.		TABLE V.—Log. Sines, etc.								22¼ Deg.		
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.		
		9·		10·	9·		10·	10·03		9·96		
21	45	568856	528	431144	600929	611	399071	2073	84	7927		15
	46	569172	527	430828	601296	611	398704	2124	84	7876		14
	47	569488	527	430512	601662	611	398338	2174	84	7826		13
	48	569804	526	430196	602029	610	397971	2225	84	7775		12
	49	570120	526	429880	602395	610	397605	2275	84	7725		11
	50	570435	525	429565	602761	610	397239	2326	84	7674		10
	51	570751	525	429249	603127	609	396873	2376	84	7624		9
	52	571066	524	428934	603493	609	396507	2427	84	7573		8
	53	571380	524	428620	603858	609	396142	2478	85	7522	68	7
21	54	571695	523	428305	604223	608	395777	2529	85	7471		6
	55	572009	523	427991	604588	608	395412	2579	85	7421		5
	56	572323	523	427677	604953	607	395047	2630	85	7370		4
	57	572636	522	427364	605317	607	394683	2681	85	7319		3
	58	572950	522	427050	605682	607	394318	2732	85	7268		2
	59	573263	521	426737	606046	606	393954	2783	85	7217		1
22	0	573575	521	426425	606410	606	393590	2834	85	7166	**68**	0
	1	573888	520	426112	606773	606	393227	2885	85	7115		59
	2	574200	520	425800	607137	605	392863	2936	85	7064	67	58
22	3	574512	519	425488	607500	605	392500	2987	85	7013		57
	4	574824	519	425176	607863	604	392137	3039	85	6961		56
	5	575136	519	424864	608225	604	391775	3090	85	6910		55
	6	575447	518	424553	608588	604	391412	3141	85	6859		54
	7	575758	518	424242	608950	603	391050	3192	85	6808		53
	8	576069	517	423931	609312	603	390688	3244	86	6756		52
	9	576379	517	423621	609674	603	390326	3295	86	6705		51
	10	576689	516	423311	610036	602	389964	3347	86	6653		50
	11	576999	516	423001	610397	602	389603	3398	86	6602	67	49
22	12	577309	516	422691	610759	602	389241	3450	86	6550		48
	13	577618	515	422382	611120	601	388880	3501	86	6499		47
	14	577927	515	422073	611480	601	388520	3553	86	6447		46
	15	578236	514	421764	611841	601	388159	3605	86	6395		45
	16	578545	514	421455	612201	600	387799	3656	86	6344		44
	17	578853	513	421147	612561	600	387439	3708	86	6292		43
	18	579162	513	420838	612921	600	387079	3760	86	6240		42
	19	579470	513	420530	613281	599	386719	3812	86	6188		41
	20	579777	512	420223	613641	599	386359	3864	86	6136	67	40
22	21	580085	512	419915	614000	598	386000	3915	87	6085		39
	22	580392	511	419608	614359	598	385641	3967	87	6033		38
	23	580699	511	419301	614718	598	385282	4019	87	5981		37
	24	581005	511	418995	615077	597	384923	4072	87	5928		36
	25	581312	510	418688	615435	597	384565	4124	87	5876		35
	26	581618	510	418382	615793	597	384207	4176	87	5824		34
	27	581924	509	418076	616151	596	383849	4228	87	5772		33
	28	582229	509	417771	616509	596	383491	4280	87	5720		32
	29	582535	509	417465	616867	596	383133	4332	87	5668		31
	30	582840	509	417160	617224	596	382776	4385	87	5615	**67**	30
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	°	′
68¼ Deg.											67½ Deg.	

22½ Deg.		TABLE V.—Log. Sines, etc.									23¼ Deg.
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·03		9·96	
22	30	582840	508	417160	617224	595	382776	4385	87	5615	30
	31	583145	508	416855	617582	595	382418	4437	87	5563	29
	32	583449	507	416551	617939	595	382061	4489	87	5511	28
	33	583754	507	416246	618295	594	381705	4542	87	5458	27
	34	584058	506	415942	618652	594	381348	4594	87	5406	26
	35	584361	506	415639	619008	594	380992	4647	88	5353	25
	36	584665	506	415335	619364	593	380636	4699	88	5301	24
	37	584968	505	415032	619721	593	380279	4752	88	5248	23
	38	585272	505	414728	620076	593	379924	4805	88	5195	67 22
22	39	585574	504	414426	620432	592	379568	4857	88	5143	21
	40	585877	504	414123	620787	592	379213	4910	88	5090	20
	41	586179	503	413821	621142	592	378858	4963	88	5037	19
	42	586482	503	413518	621497	591	378503	5016	88	4984	18
	43	586783	503	413217	621852	591	378148	5069	88	4931	17
	44	587085	502	412915	622207	590	377793	5121	88	4879	16
	45	587386	502	412614	622561	590	377439	5174	88	4826	15
	46	587688	501	412312	622915	590	377085	5227	88	4773	14
	47	587989	501	412011	623269	589	376731	5281	88	4719	67 13
22	48	588289	501	411711	623623	589	376377	5334	89	4666	12
	49	588590	500	411410	623976	589	376024	5387	89	4613	11
	50	588890	500	411110	624330	588	375670	5440	89	4560	10
	51	589190	499	410810	624683	588	375317	5493	89	4507	9
	52	589489	499	410511	625036	588	374964	5546	89	4454	8
	53	589789	499	410211	625388	587	374612	5600	89	4400	7
	54	590088	498	409912	625741	587	374259	5653	89	4347	6
	55	590387	498	409613	626093	587	373907	5706	89	4294	5
	56	590686	497	409314	626445	586	373555	5760	89	4240	67 4
22	57	590984	497	409016	626797	586	373203	5813	89	4187	3
	58	591282	497	408718	627149	586	372851	5867	89	4133	2
	59	591580	496	408420	627501	585	372499	5920	89	4080	1
23	0	591878	496	408122	627852	585	372148	5974	89	4026	67 0
	1	592176	495	407824	628203	585	371797	6028	89	3972	59
	2	592473	495	407527	628554	585	371446	6081	89	3919	58
	3	592770	495	407230	628905	584	371095	6135	89	3865	57
	4	593067	494	406933	629255	584	370745	6189	90	3811	56
	5	593363	494	406637	629606	583	370394	6243	90	3757	66 55
23	6	593659	493	406341	629956	583	370044	6296	90	3704	54
	7	593955	493	406045	630306	583	369694	6350	90	3650	53
	8	594251	493	405749	630656	583	369344	6404	90	3596	52
	9	594547	492	405453	631005	582	368995	6458	90	3542	51
	10	594842	492	405158	631355	582	368645	6512	90	3488	50
	11	595137	491	404863	631704	582	368296	6566	90	3434	49
	12	595432	491	404568	632053	581	367947	6621	90	3379	48
	13	595727	491	404273	632401	581	367599	6675	90	3325	47
	14	596021	490	403979	632750	581	367250	6729	90	3271	46
	15	596315		403685	633098		366902	6783		3217	66 45
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
67½ Deg.											66¾ Deg.

23¼ Deg.		TABLE V.—Log. Sines, etc.								24 Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·03		9·96	
23	15	596315	490	403685	633098	580	366902	6783	90	3217	45
	16	596609	489	403391	633447	580	366553	6837	90	3163	44
	17	596903	489	403097	633795	580	366205	6892	91	3108	43
	18	597196	489	402804	634143	579	365857	6946	91	3054	42
	19	597490	488	402510	634490	579	365510	7001	91	2999	41
	20	597783	488	402217	634838	579	365162	7055	91	2945	40
	21	598075	487	401925	635185	578	364815	7110	91	2890	39
	22	598368	487	401632	635532	578	364468	7164	91	2836	38
	23	598660	487	401340	635879	578	364121	7219	91	2781	66 37
23	24	598952	486	401048	636226	577	363774	7273	91	2727	36
	25	599244	486	400756	636572	577	363428	7328	91	2672	35
	26	599536	485	400464	636919	577	363081	7383	91	2617	34
	27	599827	485	400173	637265	577	362735	7438	91	2562	33
	28	600118	485	399882	637611	576	362389	7492	91	2508	32
	29	600409	484	399591	637956	576	362044	7547	91	2453	31
	30	600700	484	399300	638302	576	361698	7602	92	2398	30
	31	600990	484	399010	638647	575	361353	7657	92	2343	29
	32	601280	483	398720	638992	575	361008	7712	92	2288	66 28
23	33	601570	483	398430	639337	575	360663	7767	92	2233	27
	34	601860	482	398140	639682	574	360318	7822	92	2178	26
	35	602150	482	397850	640027	574	359973	7877	92	2123	25
	36	602439	482	397561	640371	574	359629	7933	92	2067	24
	37	602728	481	397272	640716	573	359284	7988	92	2012	23
	38	603017	481	396983	641060	573	358940	8043	92	1957	22
	39	603305	481	396695	641404	573	358596	8098	92	1902	21
	40	603594	480	396406	641747	572	358253	8154	92	1846	20
	41	603882	480	396118	642091	572	357909	8209	92	1791	66 19
23	42	604170	479	395830	642434	572	357566	8265	92	1735	18
	43	604457	479	395543	642777	572	357223	8320	92	1680	17
	44	604745	479	395255	643120	571	356880	8376	93	1624	16
	45	605032	478	394968	643463	571	356537	8431	93	1569	15
	46	605319	478	394681	643806	571	356194	8487	93	1513	14
	47	605606	478	394394	644148	570	355852	8542	93	1458	13
	48	605892	477	394108	644490	570	355510	8598	93	1402	12
	49	606179	477	393821	644832	570	355168	8654	93	1346	11
	50	606465	476	393535	645174	569	354826	8710	93	1290	66 10
23	51	606751	476	393249	645516	569	354484	8765	93	1235	9
	52	607036	476	392964	645857	569	354143	8821	93	1179	8
	53	607322	475	392678	646199	569	353801	8877	93	1123	7
	54	607607	475	392393	646540	568	353460	8933	93	1067	6
	55	607892	474	392108	646881	568	353119	8989	93	1011	5
	56	608177	474	391823	647222	568	352778	9045	93	0955	4
	57	608461	474	391539	647562	567	352438	9101	93	0899	3
	58	608745	473	391255	647903	567	352097	9157	94	0843	2
	59	609029	473	390971	648243	567	351757	9214	94	0786	1
	60	609313		390687	648583		351417	9270		0730	66 0
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
66¾ Deg.											66 Deg.

24 Deg.		TABLE V.—Log. Sines, etc.									24¾ Deg.
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·6		10·3	9·		10·	10·0		9·9	
24	0	09313	473	90687	648583	566	351417	39270	94	60730	60
	1	09597	472	90403	648923	566	351077	39326	94	60674	59
	2	09880	472	90120	649263	566	350737	39382	94	60618	58
	3	10164	472	89836	649602	566	350398	39439	94	60561	57
	4	10447	471	89553	649942	565	350058	39495	94	60505	56
	5	10729	471	89271	650281	565	349719	39552	94	60448	55
	6	11012	470	88988	650620	565	349380	39608	94	60392	54
	7	11294	470	88706	650959	564	349041	39665	94	60335	53
	8	11576	470	88424	651297	564	348703	39721	94	60279	65 52
24	9	11858	469	88142	651636	564	348364	39778	94	60222	51
	10	12140	469	87860	651974	563	348026	39835	94	60165	50
	11	12421	469	87579	652312	563	347688	39891	94	60109	49
	12	12702	468	87298	652650	563	347350	39948	95	60052	48
	13	12983	468	87017	652988	563	347012	40005	95	59995	47
	14	13264	467	86736	653326	562	346674	40062	95	59938	46
	15	13545	467	86455	653663	562	346337	40118	95	59882	45
	16	13825	467	86175	654000	562	346000	40175	95	59825	44
	17	14105	466	85895	654337	561	345663	40232	95	59768	65 43
24	18	14385	466	85615	654674	561	345326	40289	95	59711	42
	19	14665	466	85335	655011	561	344989	40346	95	59654	41
	20	14944	465	85056	655348	561	344652	40404	95	59596	40
	21	15223	465	84777	655684	560	344316	40461	95	59539	39
	22	15502	465	84498	656020	560	343980	40518	95	59482	38
	23	15781	464	84219	656356	560	343644	40575	95	59425	37
	24	16060	464	83940	656692	559	343308	40632	95	59368	36
	25	16338	464	83662	657028	559	342972	40690	96	59310	35
	26	16616	463	83384	657364	559	342636	40747	96	59253	65 34
24	27	16894	463	83106	657699	559	342301	40805	96	59195	33
	28	17172	462	82828	658034	558	341966	40862	96	59138	32
	29	17450	462	82550	658369	558	341631	40919	96	59081	31
	30	17727	462	82273	658704	558	341296	40977	96	59023	30
	31	18004	461	81996	659039	558	340961	41035	96	58965	29
	32	18281	461	81719	659373	557	340627	41092	96	58908	28
	33	18558	461	81442	659708	557	340292	41150	96	58850	27
	34	18834	460	81166	660042	557	339958	41208	96	58792	26
	35	19110	460	80890	660376	557	339624	41266	96	58734	65 25
24	36	19386	460	80614	660710	556	339290	41323	96	58677	24
	37	19662	459	80338	661043	556	338957	41381	96	58619	23
	38	19938	459	80062	661377	556	338623	41439	96	58561	22
	39	20213	459	79787	661710	555	338290	41497	97	58503	21
	40	20488	458	79512	662043	555	337957	41555	97	58445	20
	41	20763	458	79237	662376	555	337624	41613	97	58387	19
	42	21038	457	78962	662709	554	337291	41671	97	58329	18
	43	21313	457	78687	663042	554	336958	41729	97	58271	17
	44	21587	457	78413	663375	554	336625	41787	97	58213	16
	45	21861		78139	663707		336293	41846		58154	**65** 15
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
66 Deg.											65¼ Deg.

24⅜ Deg.		TABLE V.—Log. Sines, etc.							25½ Deg.	
°	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9·		10·	9·		10·	10·04		9·95	
24 45	621861	456	378139	663707	554	336293	1846	97	8154	15
46	622135	456	377865	664039	553	335961	1904	97	8096	14
47	622409	456	377591	664371	553	335629	1962	97	8038	13
48	622682	455	377318	664703	553	335297	2021	97	7979	12
49	622956	455	377044	665035	553	334965	2079	97	7921	11
50	623229	455	376771	665366	552	334634	2137	97	7863	10
51	623502	454	376498	665697	552	334303	2196	97	7804	9
52	623774	454	376226	666029	552	333971	2254	98	7746	8
53	624047	454	375953	666360	551	333640	2313	98	7687	65 7
24 54	624319	453	375681	666691	551	333309	2372	98	7628	6
55	624591	453	375409	667021	551	332979	2430	98	7570	5
56	624863	453	375137	667352	551	332648	2489	98	7511	4
57	625135	452	374865	667682	550	332318	2548	98	7452	3
58	625406	452	374594	668013	550	331987	2607	98	7393	2
59	625677	452	374323	668343	550	331657	2665	98	7335	1
25 0	625948	451	374052	668672	550	331328	2724	98	7276	**65** 0
1	626219	451	373781	669002	549	330998	2783	98	7217	59
2	626490	451	373510	669332	549	330668	2842	98	7158	64 58
25 3	626760	450	373240	669661	549	330339	2901	98	7099	57
4	627030	450	372970	669991	548	330009	2960	98	7040	56
5	627300	450	372700	670320	548	329680	3019	98	6981	55
6	627570	449	372430	670649	548	329351	3079	99	6921	54
7	627840	449	372160	670977	548	329023	3138	99	6862	53
8	628109	449	371891	671306	547	328694	3197	99	6803	52
9	628378	448	371622	671634	547	328366	3256	99	6744	51
10	628647	448	371353	671963	547	328037	3316	99	6684	50
11	628916	447	371084	672291	547	327709	3375	99	6625	64 49
25 12	629185	447	370815	672619	546	327381	3434	99	6566	48
13	629453	447	370547	672947	546	327053	3494	99	6506	47
14	629721	446	370279	673274	546	326726	3553	99	6447	46
15	629989	446	370011	673602	546	326398	3613	99	6387	45
16	630257	446	369743	673929	545	326071	3673	99	6327	44
17	630524	446	369476	674257	545	325743	3732	99	6268	43
18	630792	445	369208	674584	545	325416	3792	100	6208	42
19	631059	445	368941	674910	544	325090	3852	100	6148	41
20	631326	445	368674	675237	544	324763	3911	100	6089	64 40
25 21	631593	444	368407	675564	544	324436	3971	100	6029	39
22	631859	444	368141	675890	544	324110	4031	100	5969	38
23	632125	444	367875	676216	543	323784	4091	100	5909	37
24	632392	443	367608	676543	543	323457	4151	100	5849	36
25	632658	443	367342	676869	543	323131	4211	100	5789	35
26	632923	443	367077	677194	543	322806	4271	100	5729	34
27	633189	442	366811	677520	542	322480	4331	100	5669	33
28	633454	442	366546	677846	542	322154	4391	100	5609	32
29	633719	442	366281	678171	542	321829	4452	100	5548	31
30	633984	442	366016	678496	542	321504	4512		5488	**64** 30
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
65¼ Deg.										64¾ Deg.

25½ Deg.		TABLE V.—Log. Sines, etc.								26¼ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·04		9·95	
25	30	633984	441	366016	678496	542	321504	4512	100	5488	30
	31	634249	441	365751	678821	541	321179	4572	101	5428	29
	32	634514	440	365486	679146	541	320854	4632	101	5368	28
	33	634778	440	365222	679471	541	320529	4693	101	5307	27
	34	635042	440	364958	679795	541	320205	4753	101	5247	26
	35	635306	439	364694	680120	540	319880	4814	101	5186	25
	36	635570	439	364430	680444	540	319556	4874	101	5126	24
	37	635834	439	364166	680768	540	319232	4935	101	5065	23
	38	636097	438	363903	681092	540	318908	4995	101	5005	64 22
25	39	636360	438	363640	681416	539	318584	5056	101	4944	21
	40	636623	438	363377	681740	539	318260	5117	101	4883	20
	41	636886	437	363114	682063	539	317937	5177	101	4823	19
	42	637148	437	362852	682387	539	317613	5238	101	4762	18
	43	637411	437	362589	682710	538	317290	5299	101	4701	17
	44	637673	437	362327	683033	538	316967	5360	101	4640	16
	45	637935	436	362065	683356	538	316644	5421	101	4579	15
	46	638197	436	361803	683679	538	316321	5482	102	4518	14
	47	638458	436	361542	684001	537	315999	5543	102	4457	64 13
25	48	638720	435	361280	684324	537	315676	5604	102	4396	12
	49	638981	435	361019	684646	537	315354	5665	102	4335	11
	50	639242	435	360758	684968	537	315032	5726	102	4274	10
	51	639503	435	360497	685290	536	314710	5787	102	4213	9
	52	639764	434	360236	685612	536	314388	5848	102	4152	8
	53	640024	434	359976	685934	536	314066	5910	102	4090	7
	54	640284	434	359716	686255	536	313745	5971	102	4029	6
	55	640544	433	359456	686577	535	313423	6032	101	3968	5
	56	640804	433	359196	686898	535	313102	6094	102	3906	64 4
25	57	641064	433	358936	687219	535	312781	6155	102	3845	3
	58	641324	432	358676	687540	535	312460	6217	102	3783	2
	59	641584	432	358416	687861	534	312139	6278	103	3722	1
26	0	641842	432	358158	688182	534	311818	6340	103	3660	**64** 0
	1	642101	431	357899	688502	534	311498	6401	103	3599	59
	2	642360	431	357640	688823	534	311177	6463	103	3537	58
	3	642618	431	357382	689143	533	310857	6525	103	3475	57
	4	642877	430	357123	689463	533	310537	6587	103	3413	56
	5	643135	430	356865	689783	533	310217	6648	103	3352	63 55
26	6	643393	430	356607	690103	533	309897	6710	103	3290	54
	7	643650	429	356350	690423	533	309577	6772	103	3228	53
	8	643908	429	356092	690742	532	309258	6834	103	3166	52
	9	644165	429	355835	691062	532	308938	6896	103	3104	51
	10	644423	428	355577	691381	532	308619	6958	103	3042	50
	11	644680	428	355320	691700	531	308300	7020	104	2980	49
	12	644936	428	355064	692019	531	307981	7082	104	2918	48
	13	645193	427	354807	692338	531	307662	7145	104	2855	47
	14	645450	427	354550	692656	531	307344	7207	104	2793	46
	15	645706		354294	692975		307025	7269		2731	**63** 45
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
64½ Deg.											63¾ Deg.

26¼ Deg.		TABLE V.—Log Sines, etc.									27 Deg
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·6		10·3	9·		10·	10·0		9·9	
26	15	45706	427	54294	692975	531	307025	47269	104	52731	45
	16	45962	426	54038	693293	530	306707	47331	104	52669	44
	17	46218	426	53782	693612	530	306388	47394	104	52606	43
	18	46474	426	53526	693930	530	306070	47456	104	52544	42
	19	46729	425	53271	694248	530	305752	47519	104	52481	41
	20	46984	425	53016	694566	529	305434	47581	104	52419	40
	21	47240	425	52760	694883	529	305117	47644	104	52356	39
	22	47494	424	52506	695201	529	304799	47706	104	52294	38
	23	47749	424	52251	695518	529	304482	47769	104	52231	63 37
26	24	48004	424	51996	695836	529	304164	47832	105	52168	36
	25	48258	424	51742	696153	528	303847	47894	105	52106	35
	26	48512	423	51488	696470	528	303530	47957	105	52043	34
	27	48766	423	51234	696787	528	303213	48020	105	51980	33
	28	49020	423	50980	697103	528	302897	48083	105	51917	32
	29	49274	422	50726	697420	527	302580	48146	105	51854	31
	30	49527	422	50473	697736	527	302264	48209	105	51791	30
	31	49781	422	50219	698053	527	301947	48272	105	51728	29
	32	50034	422	49966	698369	527	301631	48335	105	51665	63 28
26	33	50287	421	49713	698685	526	301315	48398	105	51602	27
	34	50539	421	49461	699001	526	300999	48461	105	51539	26
	35	50792	421	49208	699316	526	300684	48524	105	51476	25
	36	51044	420	48956	699632	526	300368	48588	105	51412	24
	37	51297	420	48703	699947	526	300053	48651	106	51349	23
	38	51549	420	48451	700263	525	299737	48714	106	51286	22
	39	51800	419	48200	700578	525	299422	48778	106	51222	21
	40	52052	419	47948	700893	525	299107	48841	106	51159	20
	41	52304	419	47696	701208	524	298792	48904	106	51096	63 19
26	42	52555	418	47445	701523	524	298477	48968	106	51032	18
	43	52806	418	47194	701837	524	298163	49032	106	50968	17
	44	53057	418	46943	702152	524	297848	49095	106	50905	16
	45	53308	418	46692	702466	524	297534	49159	106	50841	15
	46	53558	417	46442	702780	523	297220	49222	106	50778	14
	47	53808	417	46192	703095	523	296905	49286	106	50714	13
	48	54059	417	45941	703409	523	296591	49350	106	50650	12
	49	54309	416	45691	703723	523	296277	49414	106	50586	11
	50	54558	416	45442	704036	522	295964	49478	107	50522	63 10
26	51	54808	416	45192	704350	522	295650	49542	107	50458	9
	52	55058	416	44942	704663	522	295337	49606	107	50394	8
	53	55307	415	44693	704977	522	295023	49670	107	50330	7
	54	55556	415	44444	705290	522	294710	49734	107	50266	6
	55	55805	415	44195	705603	521	294397	49798	107	50202	5
	56	56054	414	43946	705916	521	294084	49862	107	50138	4
	57	56302	414	43698	706228	521	293772	49926	107	50074	3
	58	56551	414	43449	706541	521	293459	49990	107	50010	2
	59	56799	414	43201	706854	521	293146	50055	107	49945	1
	60	57047	413	42953	707166	521	292834	50119	107	49881	**63** 0
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
63¾ Deg.											63 Deg.

27 Deg.		TABLE V.—Log. Sines, etc.									27¾ Deg.
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·05		9·94	
27	0	657047	413	342953	707166	520	292834	0119	107	9881	60
	1	657295	413	342705	707478	520	292522	0184	107	9816	59
	2	657542	412	342458	707790	520	292210	0248	107	9752	58
	3	657790	412	342210	708102	520	291898	0312	108	9688	57
	4	658037	412	341963	708414	519	291586	0377	108	9623	56
	5	658284	412	341716	708726	519	291274	0442	108	9558	55
	6	658531	411	341469	709037	519	290963	0506	108	9494	54
	7	658778	411	341222	709349	519	290651	0571	108	9429	53
	8	659025	411	340975	709660	519	290340	0636	108	9364	62 52
27	9	659271	410	340729	709971	518	290029	0700	108	9300	51
	10	659517	410	340483	710282	518	289718	0765	108	9235	50
	11	659763	410	340237	710593	518	289407	0830	108	9170	49
	12	660009	409	339991	710904	518	289096	0895	108	9105	48
	13	660255	409	339745	711215	518	288785	0960	108	9040	47
	14	660501	409	339499	711525	517	288475	1025	108	8975	46
	15	660746	409	339254	711836	517	288164	1090	108	8910	45
	16	660991	408	339009	712146	517	287854	1155	108	8845	44
	17	661236	408	338764	712456	517	287544	1220	109	8780	62 43
27	18	661481	408	338519	712766	516	287234	1285	109	8715	42
	19	661726	407	338274	713076	516	286924	1350	109	8650	41
	20	661970	407	338030	713386	516	286614	1416	109	8584	40
	21	662214	407	337786	713696	516	286304	1481	109	8519	39
	22	662459	407	337541	714005	516	285995	1546	109	8454	38
	23	662703	406	337297	714314	515	285686	1612	109	8388	37
	24	662946	406	337054	714624	515	285376	1677	109	8323	36
	25	663190	406	336810	714933	515	285067	1743	109	8257	35
	26	663433	405	336567	715242	515	284758	1808	109	8192	62 34
27	27	663677	405	336323	715551	514	284449	1874	109	8126	33
	28	663920	405	336080	715860	514	284140	1940	109	8060	32
	29	664163	405	335837	716168	514	283832	2005	110	7995	31
	30	664406	404	335594	716477	514	283523	2071	110	7929	30
	31	664648	404	335352	716785	514	283215	2137	110	7863	29
	32	664891	404	335109	717093	513	282907	2203	110	7797	28
	33	665133	403	334867	717401	513	282599	2269	110	7731	27
	34	665375	403	334625	717709	513	282291	2335	110	7665	26
	35	665617	403	334383	718017	513	281983	2400	110	7600	62 25
27	36	665859	402	334141	718325	513	281675	2467	110	7533	24
	37	666100	402	333900	718633	512	281367	2533	110	7467	23
	38	666342	402	333658	718940	512	281060	2599	110	7401	22
	39	666583	402	333417	719248	512	280752	2665	110	7335	21
	40	666824	401	333176	719555	512	280445	2731	110	7269	20
	41	667065	401	332935	719862	512	280138	2797	110	7203	19
	42	667305	401	332695	720169	511	279831	2864	111	7136	18
	43	667546	401	332454	720476	511	279524	2930	111	7070	17
	44	667786	400	332214	720783	511	279217	2996	111	7004	16
	45	668027		331973	721089		278911	3063		6937	62 15
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
63 Deg.											62¼ Deg.

27¾ Deg.		TABLE V.—Log. Sines, etc.								28¼ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·05		9·94	
27	45	668027	400	331973	721089	511	278911	3063	111	6937	15
	46	668267	400	331733	721396	511	278604	3129	111	6871	14
	47	668506	399	331494	721702	510	278298	3196	111	6804	13
	48	668746	399	331254	722009	510	277991	3262	111	6738	12
	49	668986	399	331014	722315	510	277685	3329	111	6671	11
	50	669225	399	330775	722621	510	277379	3396	111	6604	10
	51	669464	398	330536	722927	510	277073	3462	111	6538	9
	52	669703	398	330297	723232	509	276768	3529	111	6471	8
	53	669942	398	330058	723538	509	276462	3596	111	6404	62 7
27	54	670181	397	329819	723844	509	276156	3663	111	6337	6
	55	670419	397	329581	724149	509	275851	3730	112	6270	5
	56	670658	397	329342	724454	509	275546	3797	112	6203	4
	57	670896	397	329104	724759	508	275241	3864	112	6136	3
	58	671134	396	328866	725065	508	274935	3931	112	6069	2
	59	671372	396	328628	725369	508	274631	3998	112	6002	1
28	0	671609	396	328391	725674	508	274326	4065	112	5935	**62** 0
	1	671847	395	328153	725979	508	274021	4132	112	5868	59
	2	672084	395	327916	726284	507	273716	4200	112	5800	61 58
28	3	672321	395	327679	726588	507	273412	4267	112	5733	57
	4	672558	395	327442	726892	507	273108	4334	112	5666	56
	5	672795	394	327205	727197	507	272803	4402	112	5598	55
	6	673032	394	326968	727501	507	272499	4469	112	5531	54
	7	673268	394	326732	727805	506	272195	4536	113	5464	53
	8	673505	394	326495	728109	506	271891	4604	113	5396	52
	9	673741	393	326259	728412	506	271588	4672	113	5328	51
	10	673977	393	326023	728716	506	271284	4739	113	5261	50
	11	674213	393	325787	729020	506	270980	4807	113	5193	61 49
28	12	674448	392	325552	729323	505	270677	4875	113	5125	48
	13	674684	392	325316	729626	505	270374	4942	113	5058	47
	14	674919	392	325081	729929	505	270071	5010	113	4990	46
	15	675155	392	324845	730233	505	269767	5078	113	4922	45
	16	675390	391	324610	730535	505	269465	5146	113	4854	44
	17	675624	391	324376	730838	504	269162	5214	113	4786	43
	18	675859	391	324141	731141	504	268859	5282	113	4718	42
	19	676094	391	323906	731444	504	268556	5350	113	4650	41
	20	676328	390	323672	731746	504	268254	5418	114	4582	61 40
28	21	676562	390	323438	732048	504	267952	5486	114	4514	39
	22	676796	390	323204	732351	503	267649	5554	114	4446	38
	23	677030	390	322970	732653	503	267347	5623	114	4377	37
	24	677264	389	322736	732955	503	267045	5691	114	4309	36
	25	677498	389	322502	733257	503	266743	5759	114	4241	35
	26	677731	389	322269	733558	503	266442	5828	114	4172	34
	27	677964	388	322036	733860	502	266140	5896	114	4104	33
	28	678197	388	321803	734162	502	265838	5964	114	4036	32
	29	678430	388	321570	734463	502	265537	6033	114	3967	31
	30	678663	388	321337	734764	502	265236	6101	114	3899	**61** 30
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
62¼ Deg.											61¼ Deg.

28½ Deg.		TABLE V.—Log. Sines, etc.								29¼ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·05		9·94	
28	30	678663	388	321337	734764	502	265236	6101	114	3899	30
	31	678895	387	321105	735066	502	264934	6170	114	3830	29
	32	679128	387	320872	735367	502	264633	6239	114	3761	28
	33	679360	387	320640	735668	501	264332	6307	115	3693	27
	34	679592	387	320408	735969	501	264031	6376	115	3624	26
	35	679824	386	320176	736269	501	263731	6445	115	3555	25
	36	680056	386	319944	736570	501	263430	6514	115	3486	24
	37	680288	386	319712	736871	501	263129	6583	115	3417	23
	38	680519	385	319481	737171	500	262829	6652	115	3348	61 22
28	39	680750	385	319250	737471	500	262529	6721	115	3279	21
	40	680982	385	319018	737771	500	262229	6790	115	3210	20
	41	681213	385	318787	738071	500	261929	6859	115	3141	19
	42	681443	384	318557	738371	500	261629	6928	115	3072	18
	43	681674	384	318326	738671	499	261329	6997	115	3003	17
	44	681905	384	318095	738971	499	261029	7066	115	2934	16
	45	682135	384	317865	739271	499	260729	7136	115	2864	15
	46	682365	383	317635	739570	499	260430	7205	116	2795	14
	47	682595	383	317405	739870	499	260130	7274	116	2726	61 13
28	48	682825	383	317175	740169	499	259831	7344	116	2656	12
	49	683055	383	316945	740468	498	259532	7413	116	2587	11
	50	683284	382	316716	740767	498	259233	7483	116	2517	10
	51	683514	382	316486	741066	498	258934	7552	116	2448	9
	52	683743	382	316257	741365	498	258635	7622	116	2378	8
	53	683972	382	316028	741664	498	258336	7692	116	2308	7
	54	684201	381	315799	741962	497	258038	7761	116	2239	6
	55	684430	381	315570	742261	497	257739	7831	116	2169	5
	56	684658	381	315342	742559	497	257441	7901	116	2099	61 4
28	57	684887	380	315113	742858	497	257142	7971	116	2029	3
	58	685115	380	314885	743156	497	256844	8041	116	1959	2
	59	685343	380	314657	743454	497	256546	8111	117	1889	1
29	0	685571	380	314429	743752	496	256248	8181	117	1819	**61** 0
	1	685799	379	314201	744050	496	255950	8251	117	1749	59
	2	686027	379	313973	744348	496	255652	8321	117	1679	58
	3	686254	379	313746	744645	496	255355	8391	117	1609	57
	4	686482	379	313518	744943	496	255057	8461	117	1539	56
	5	686709	378	313291	745240	495	254760	8531	117	1469	60 55
29	6	686936	378	313064	745538	495	254462	8602	117	1398	54
	7	687163	378	312837	745835	495	254165	8672	117	1328	53
	8	687389	378	312611	746132	495	253868	8742	117	1258	52
	9	687616	377	312384	746429	495	253571	8813	117	1187	51
	10	687843	377	312157	746726	495	253274	8883	117	1117	50
	11	688069	377	311931	747023	494	252977	8954	118	1046	49
	12	688295	377	311705	747319	494	252681	9025	118	0975	48
	13	688521	376	311479	747616	494	252384	9095	118	0905	47
	14	688747	376	311253	747913	494	252087	9166	118	0834	46
	15	688972		311028	748209		251791	9237		0763	**60** 45
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
61½ Deg.										60¾ Deg.	

29¼ Deg.				TABLE V.—Log. Sines, etc.						30 Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·6		10·3	9·		10·	10·0		9·9	
29	15	88972	376	11028	748209	494	251791	59237	118	40763	45
	16	89198	376	10802	748505	493	251495	59307	118	40693	44
	17	89423	375	10577	748801	493	251199	59378	118	40622	43
	18	89648	375	10352	749097	493	250903	59449	118	40551	42
	19	89873	375	10127	749393	493	250607	59520	118	40480	41
	20	90098	375	09902	749689	493	250311	59591	118	40409	40
	21	90323	374	09677	749985	493	250015	59662	118	40338	39
	22	90548	374	09452	750281	492	249719	59733	118	40267	38
	23	90772	374	09228	750576	492	249424	59804	118	40196	60 37
29	24	90996	374	09004	750872	492	249128	59875	119	40125	36
	25	91220	373	08780	751167	492	248833	59946	119	40054	35
	26	91444	373	08556	751462	492	248538	60018	119	39982	34
	27	91668	373	08332	751757	492	248243	60089	119	39911	33
	28	91892	373	08108	752052	491	247948	60160	119	39840	32
	29	92115	372	07885	752347	491	247653	60232	119	39768	31
	30	92339	372	07661	752642	491	247358	60303	119	39697	30
	31	92562	372	07438	752937	491	247063	60375	119	39625	29
	32	92785	371	07215	753231	491	246769	60446	119	39554	60 28
29	33	93008	371	06992	753526	491	246474	60518	119	39482	27
	34	93231	371	06769	753820	490	246180	60590	119	39410	26
	35	93453	371	06547	754115	490	245885	60661	119	39339	25
	36	93676	370	06324	754409	490	245591	60733	120	39267	24
	37	93898	370	06102	754703	490	245297	60805	120	39195	23
	38	94120	370	05880	754997	490	245003	60877	120	39123	22
	39	94342	370	05658	755291	490	244709	60948	120	39052	21
	40	94564	369	05436	755585	489	244415	61020	120	38980	20
	41	94786	369	05214	755878	489	244122	61092	120	38908	60 19
29	42	95007	369	04993	756172	489	243828	61164	120	38836	18
	43	95229	369	04771	756465	489	243535	61237	120	38763	17
	44	95450	368	04550	756759	489	243241	61309	120	38691	16
	45	95671	368	04329	757052	489	242948	61381	120	38619	15
	46	95892	368	04108	757345	488	242655	61453	120	38547	14
	47	96113	368	03887	757638	488	242362	61525	120	38475	13
	48	96334	367	03666	757931	488	242069	61598	121	38402	12
	49	96554	367	03446	758224	488	241776	61670	121	38330	11
	50	96775	367	03225	758517	488	241483	61742	121	38258	60 10
29	51	96995	367	03005	758810	488	241190	61815	121	38185	9
	52	97215	366	02785	759102	487	240898	61887	121	38113	8
	53	97435	366	02565	759395	487	240605	61960	121	38040	7
	54	97654	366	02346	759687	487	240313	62033	121	37967	6
	55	97874	366	02126	759979	487	240021	62105	121	37895	5
	56	98094	365	01906	760272	487	239728	62178	121	37822	4
	57	98313	365	01687	760564	487	239436	62251	121	37749	3
	58	98532	365	01468	760856	486	239144	62324	121	37676	2
	59	98751	365	01249	761148	486	238852	62396	121	37604	1
	60	98970		01030	761439		238561	62469		37531	**60** 0
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
60¾ Deg.											60 Deg.

30 Deg.		TABLE V.—Log. Sines, etc.									30¾ Deg.
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·06		9·93	
30	0	698970	364	301030	761439	486	238561	2469	121	7531	60
	1	699189	364	300811	761731	486	238269	2542	122	7458	59
	2	699407	364	300593	762023	486	237977	2615	122	7385	58
	3	699626	364	300374	762314	486	237686	2688	122	7312	57
	4	699844	363	300156	762606	485	237394	2762	122	7238	56
	5	700062	363	299938	762897	485	237103	2835	122	7165	55
	6	700280	363	299720	763188	485	236812	2908	122	7092	54
	7	700498	363	299502	763479	485	236521	2981	122	7019	53
	8	700716	363	299284	763770	485	236230	3054	122	6946	59 52
30	9	700933	362	299067	764061	485	235939	3128	122	6872	51
	10	701151	362	298849	764352	484	235648	3201	122	6799	50
	11	701368	362	298632	764643	484	235357	3275	122	6725	49
	12	701585	362	298415	764933	484	235067	3348	123	6652	48
	13	701802	361	298198	765224	484	234776	3422	123	6578	47
	14	702019	361	297981	765514	484	234486	3495	123	6505	46
	15	702236	361	297764	765805	484	234195	3569	123	6431	45
	16	702452	361	297548	766095	484	233905	3643	123	6357	44
	17	702669	360	297331	766385	483	233615	3716	123	6284	59 43
30	18	702885	360	297115	766675	483	233325	3790	123	6210	42
	19	703101	360	296899	766965	483	233035	3864	123	6136	41
	20	703317	360	296683	767255	483	232745	3938	123	6062	40
	21	703533	359	296467	767545	483	232455	4012	123	5988	39
	22	703749	359	296251	767834	483	232166	4086	123	5914	38
	23	703964	359	296036	768124	482	231876	4160	123	5840	37
	24	704179	359	295821	768413	482	231587	4234	124	5766	36
	25	704395	359	295605	768703	482	231297	4308	124	5692	35
	26	704610	358	295390	768992	482	231008	4382	124	5618	59 34
30	27	704825	358	295175	769281	482	230719	4457	124	5543	33
	28	705040	358	294960	769570	482	230430	4531	124	5469	32
	29	705254	358	294746	769860	481	230140	4605	124	5395	31
	30	705469	357	294531	770148	481	229852	4680	124	5320	30
	31	705683	357	294317	770437	481	229563	4754	124	5246	29
	32	705898	357	294102	770726	481	229274	4829	124	5171	28
	33	706112	357	293888	771015	481	228985	4903	124	5097	27
	34	706326	357	293674	771303	481	228697	4978	124	5022	26
	35	706539	356	293461	771592	481	228408	5052	124	4948	59 25
30	36	706753	356	293247	771880	480	228120	5127	124	4873	24
	37	706967	356	293033	772168	480	227832	5202	124	4798	23
	38	707180	355	292820	772457	480	227543	5277	125	4723	22
	39	707393	355	292607	772745	480	227255	5351	125	4649	21
	40	707606	355	292394	773033	480	226967	5426	125	4574	20
	41	707819	355	292181	773321	480	226679	5501	125	4499	19
	42	708032	355	291968	773608	480	226392	5576	125	4424	18
	43	708245	354	291755	773896	479	226104	5651	125	4349	17
	44	708458	354	291542	774184	479	225816	5726	125	4274	16
	45	708670	354	291330	774471	479	225529	5801	125	4199	**59** 15
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
60 Deg.											59¼ Deg.

TABLE V.—Log. Sines, etc.

°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.		
		9·		10·	9·		10·	10·06		9·93		
30	45	708670	354	291330	774471	479	225529	5801	125	4199		15
	46	708882	353	291118	774759	479	225241	5877	125	4123		14
	47	709094	353	290906	775046	479	224954	5952	125	4048		13
	48	709306	353	290694	775333	479	224667	6027	125	3973		12
	49	709518	353	290482	775621	478	224379	6102	126	3898		11
	50	709730	353	290270	775908	478	224092	6178	126	3822		10
	51	709941	352	290059	776195	478	223805	6253	126	3747		9
	52	710153	352	289847	776482	478	223518	6329	126	3671		8
	53	710364	352	289636	776769	478	223231	6404	126	3596	59	7
30	54	710575	352	289425	777055	478	222945	6480	126	3520		6
	55	710786	351	289214	777342	478	222658	6555	126	3445		5
	56	710997	351	289003	777628	477	222372	6631	126	3369		4
	57	711208	351	288792	777915	477	222085	6707	126	3293		3
	58	711419	351	288581	778201	477	221799	6783	126	3217		2
	59	711629	350	288371	778487	477	221513	6859	126	3141		1
31	0	711839	350	288161	778774	477	221226	6934	126	3066	**59**	0
	1	712050	350	287950	779060	477	220940	7010	127	2990		59
	2	712260	350	287740	779346	476	220654	7086	127	2914	58	58
31	3	712469	349	287531	779632	476	220368	7162	127	2838		57
	4	712679	349	287321	779918	476	220082	7238	127	2762		56
	5	712889	349	287111	780203	476	219797	7315	127	2685		55
	6	713098	349	286902	780489	476	219511	7391	127	2609		54
	7	713308	349	286692	780775	476	219225	7467	127	2533		53
	8	713517	348	286483	781060	476	218940	7543	127	2457		52
	9	713726	348	286274	781346	475	218654	7620	127	2380		51
	10	713935	348	286065	781631	475	218369	7696	127	2304		50
	11	714144	348	285856	781916	475	218084	7772	127	2228	58	49
31	12	714352	347	285648	782201	475	217799	7849	127	2151		48
	13	714561	347	285439	782486	475	217514	7925	128	2075		47
	14	714769	347	285231	782771	475	217229	8002	128	1998		46
	15	714978	347	285022	783056	475	216944	8079	128	1921		45
	16	715186	347	284814	783341	475	216659	8155	128	1845		44
	17	715394	346	284606	783626	474	216374	8232	128	1768		43
	18	715602	346	284398	783910	474	216090	8309	128	1691		42
	19	715809	346	284191	784195	474	215805	8386	128	1614		41
	20	716017	346	283983	784479	474	215521	8463	128	1537	58	40
31	21	716224	345	283776	784764	474	215236	8540	128	1460		39
	22	716432	345	283568	785048	474	214952	8617	128	1383		38
	23	716639	345	283361	785332	473	214668	8694	128	1306		37
	24	716846	345	283154	785616	473	214384	8771	129	1229		36
	25	717053	345	282947	785900	473	214100	8848	129	1152		35
	26	717259	344	282741	786184	473	213816	8925	129	1075		34
	27	717466	344	282534	786468	473	213532	9002	129	0998		33
	28	717673	344	282327	786752	473	213248	9079	129	0921		32
	29	717879	344	282121	787036	473	212964	9157	129	0843		31
	30	718085		281915	787319		212681	9234		0766	**58**	30
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	°	′

30¾ Deg. 31½ Deg.

59¼ Deg. 58½ Deg.

31½ Deg.		TABLE V.—Log. Sines, etc.								32¼ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·7		10·2	9·		10·	10·0		9·9	
31	30	18085	343	81915	787319	472	212681	69234	129	30766	30
	31	18291	343	81709	787603	472	212397	69312	129	30688	29
	32	18497	343	81503	787886	472	212114	69389	129	30611	28
	33	18703	343	81297	788170	472	211830	69467	129	30533	27
	34	18909	343	81091	788453	472	211547	69544	129	30456	26
	35	19114	342	80886	788736	472	211264	69622	129	30378	25
	36	19320	342	80680	789019	472	210981	69700	130	30300	24
	37	19525	342	80475	789302	471	210698	69777	130	30223	23
	38	19730	342	80270	789585	471	210415	69855	130	30145	58 22
31	39	19935	341	80065	789868	471	210132	69933	130	30067	21
	40	20140	341	79860	790151	471	209849	70011	130	29989	20
	41	20345	341	79655	790433	471	209567	70089	130	29911	19
	42	20549	341	79451	790716	471	209284	70167	130	29833	18
	43	20754	340	79246	790999	471	209001	70245	130	29755	17
	44	20958	340	79042	791281	471	208719	70323	130	29677	16
	45	21162	340	78838	791563	470	208437	70401	130	29599	15
	46	21366	340	78634	791846	470	208154	70479	130	29521	14
	47	21570	340	78430	792128	470	207872	70558	130	29442	58 13
31	48	21774	339	78226	792410	470	207590	70636	131	29364	12
	49	21978	339	78022	792692	470	207308	70714	131	29286	11
	50	22181	339	77819	792974	470	207026	70793	131	29207	10
	51	22385	339	77615	793256	470	206744	70871	131	29129	9
	52	22588	339	77412	793538	469	206462	70950	131	29050	8
	53	22791	338	77209	793819	469	206181	71028	131	28972	7
	54	22994	338	77006	794101	469	205899	71107	131	28893	6
	55	23197	338	76803	794383	469	205617	71185	131	28815	5
	56	23400	338	76600	794664	469	205336	71264	131	28736	58 4
31	57	23603	337	76397	794945	469	205055	71343	131	28657	3
	58	23805	337	76195	795227	469	204773	71422	131	28578	2
	59	24007	337	75993	795508	468	204492	71501	131	28499	1
32	0	24210	337	75790	795789	468	204211	71580	132	28420	**58** 0
	1	24412	337	75588	796070	468	203930	71658	132	28342	59
	2	24614	336	75386	796351	468	203649	71737	132	28263	58
	3	24816	336	75184	796632	468	203368	71817	132	28183	57
	4	25017	336	74983	796913	468	203087	71896	132	28104	56
	5	25219	336	74781	797194	468	202806	71975	132	28025	57 55
32	6	25420	335	74580	797475	468	202525	72054	132	27946	54
	7	25622	335	74378	797755	468	202245	72133	132	27867	53
	8	25823	335	74177	798036	467	201964	72213	132	27787	52
	9	26024	335	73976	798316	467	201684	72292	132	27708	51
	10	26225	335	73775	798596	467	201404	72371	132	27629	50
	11	26426	334	73574	798877	467	201123	72451	132	27549	49
	12	26626	334	73374	799157	467	200843	72530	133	27470	48
	13	26827	334	73173	799437	467	200563	72610	133	27390	47
	14	27027	334	72973	799717	467	200283	72690	133	27310	46
	15	27228		72772	799997		200003	72769	133	27231	**57** 45
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
58½ Deg.											57¾ Deg.

32¼ Deg.		TABLE V.—Log. Sines, etc.								33 Deg.		
°	′	Sine.	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.		
		9·		10·	9·		10·	10·07		9·92		
32	15	727228	334	272772	799997	466	200003	2769	133	7231		45
	16	727428	333	272572	800277	466	199723	2849	133	7151		44
	17	727628	333	272372	800557	466	199443	2929	133	7071		43
	18	727828	333	272172	800836	466	199164	3009	133	6991		42
	19	728027	333	271973	801116	466	198884	3089	133	6911		41
	20	728227	333	271773	801396	466	198604	3169	133	6831		40
	21	728427	333	271573	801675	466	198325	3249	133	6751		39
	22	728626	332	271374	801955	466	198045	3329	133	6671		38
	23	728825	332	271175	802234	465	197766	3409	133	6591	57	37
32	24	729024	332	270976	802513	465	197487	3489	134	6511		36
	25	729223	331	270777	802792	465	197208	3569	134	6431		35
	26	729422	331	270578	803072	465	196928	3649	134	6351		34
	27	729621	331	270379	803351	465	196649	3730	134	6270		33
	28	729820	331	270180	803630	465	196370	3810	134	6190		32
	29	730018	330	269982	803908	465	196092	3890	134	6110		31
	30	730216	330	269784	804187	465	195813	3971	134	6029		30
	31	730415	330	269585	804466	464	195534	4051	134	5949		29
	32	730613	330	269387	804745	464	195255	4132	134	5868	57	28
32	33	730811	330	269189	805023	464	194977	4212	134	5788		27
	34	731009	329	268991	805302	464	194698	4293	134	5707		26
	35	731206	329	268794	805580	464	194420	4374	134	5626		25
	36	731404	329	268596	805859	464	194141	4455	135	5545		24
	37	731602	329	268398	806137	464	193863	4535	135	5465		23
	38	731799	329	268201	806415	463	193585	4616	135	5384		22
	39	731996	328	268004	806693	463	193307	4697	135	5303		21
	40	732193	328	267807	806971	463	193029	4778	135	5222		20
	41	732390	328	267610	807249	463	192751	4859	135	5141	57	19
32	42	732587	328	267413	807527	463	192473	4940	135	5060		18
	43	732784	328	267216	807805	463	192195	5021	135	4979		17
	44	732980	327	267020	808083	463	191917	5103	135	4897		16
	45	733177	327	266823	808361	463	191639	5184	135	4816		15
	46	733373	327	266627	808638	462	191362	5265	136	4735		14
	47	733569	327	266431	808916	462	191084	5346	136	4654		13
	48	733765	327	266235	809193	462	190807	5428	136	4572		12
	49	733961	326	266039	809471	462	190529	5509	136	4491		11
	50	734157	326	265843	809748	462	190252	5591	136	4409	57	10
32	51	734353	326	265647	810025	462	189975	5672	136	4328		9
	52	734549	326	265451	810302	462	189698	5754	136	4246		8
	53	734744	325	265256	810580	462	189420	5836	136	4164		7
	54	734939	325	265061	810857	462	189143	5917	136	4083		6
	55	735135	325	264865	811134	461	188866	5999	136	4001		5
	56	735330	325	264670	811410	461	188590	6081	136	3919		4
	57	735525	325	264475	811687	461	188313	6163	136	3837		3
	58	735719	324	264281	811964	461	188036	6245	137	3755		2
	59	735914	324	264086	812241	461	187759	6327	137	3673		1
	60	736109		263891	812517		187483	6409	137	3591	**57**	0
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	°	′
57¾ Deg.											57 Deg.	

33 Deg.		TABLE V.—Log. Sines, etc.									33¾ Deg.
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·7		10·2	9·		10·	10·0		9·9	
33	0	36109	324	63891	812517	461	187483	76409	137	23591	60
	1	36303	324	63697	812794	461	187206	76491	137	23509	59
	2	36498	324	63502	813070	461	186930	76573	137	23427	58
	3	36692	323	63308	813347	460	186653	76655	137	23345	57
	4	36886	323	63114	813623	460	186377	76737	137	23263	56
	5	37080	323	62920	813899	460	186101	76819	137	23181	55
	6	37274	323	62726	814175	460	185825	76902	137	23098	54
	7	37467	323	62533	814452	460	185548	76984	137	23016	53
	8	37661	322	62339	814728	460	185272	77067	137	22933	56 52
33	9	37855	322	62145	815004	460	184996	77149	137	22851	51
	10	38048	322	61952	815279	460	184721	77232	138	22768	50
	11	38241	322	61759	815555	459	184445	77314	138	22686	49
	12	38434	322	61566	815831	459	184169	77397	138	22603	48
	13	38627	321	61373	816107	459	183893	77480	138	22520	47
	14	38820	321	61180	816382	459	183618	77562	138	22438	46
	15	39013	321	60987	816658	459	183342	77645	138	22355	45
	16	39206	321	60794	816933	459	183067	77728	138	22272	44
	17	39398	321	60602	817209	459	182791	77811	138	22189	56 43
33	18	39590	320	60410	817484	459	182516	77894	138	22106	42
	19	39783	320	60217	817759	459	182241	77977	138	22023	41
	20	39975	320	60025	818035	458	181965	78060	138	21940	40
	21	40167	320	59833	818310	458	181690	78143	139	21857	39
	22	40359	320	59641	818585	458	181415	78226	139	21774	38
	23	40550	319	59450	818860	458	181140	78309	139	21691	37
	24	40742	319	59258	819135	458	180865	78393	139	21607	36
	25	40934	319	59066	819410	458	180590	78476	139	21524	35
	26	41125	319	58875	819684	458	180316	78559	139	21441	56 34
33	27	41316	319	58684	819959	458	180041	78643	139	21357	33
	28	41508	318	58492	820234	458	179766	78726	139	21274	32
	29	41699	318	58301	820508	457	179492	78810	139	21190	31
	30	41889	318	58111	820783	457	179217	78893	139	21107	30
	31	42080	318	57920	821057	457	178943	78977	139	21023	29
	32	42271	318	57729	821332	457	178668	79061	140	20939	28
	33	42462	317	57538	821606	457	178394	79144	140	20856	27
	34	42652	317	57348	821880	457	178120	79228	140	20772	26
	35	42842	317	57158	822154	457	177846	79312	140	20688	56 25
33	36	43033	317	56967	822429	457	177571	79396	140	20604	24
	37	43223	317	56777	822703	457	177297	79480	140	20520	23
	38	43413	316	56587	822977	456	177023	79564	140	20436	22
	39	43602	316	56398	823250	456	176750	79648	140	20352	21
	40	43792	316	56208	823524	456	176476	79732	140	20268	20
	41	43982	316	56018	823798	456	176202	79816	140	20184	19
	42	44171	316	55829	824072	456	175928	79901	140	20099	18
	43	44361	315	55639	824345	456	175655	79985	140	20015	17
	44	44550	315	55450	824619	456	175381	80069	141	19931	16
	45	44739		55261	824893		175107	80154		19846	**56** 15
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
57 Deg.											56¼ Deg.

33¾ Deg.		TABLE V.—Log. Sines, etc.								34¼ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·08		9·91	
33	45	744739	315	255261	824893	456	175107	0154	141	9846	15
	46	744928	315	255072	825166	456	174834	0238	141	9762	14
	47	745117	315	254883	825439	455	174561	0323	141	9677	13
	48	745306	314	254694	825713	455	174287	0407	141	9593	12
	49	745494	314	254506	825986	455	174014	0492	141	9508	11
	50	745683	314	254317	826259	455	173741	0576	141	9424	10
	51	745871	314	254129	826532	455	173468	0661	141	9339	9
	52	746059	314	253941	826805	455	173195	0746	141	9254	8
	53	746248	313	253752	827078	455	172922	0831	141	9169	56 7
33	54	746436	313	253564	827351	455	172649	0915	141	9085	6
	55	746624	313	253376	827624	455	172376	1000	141	9000	5
	56	746812	313	253188	827897	454	172103	1085	142	8915	4
	57	746999	313	253001	828170	454	171830	1170	142	8830	3
	58	747187	312	252813	828442	454	171558	1255	142	8745	2
	59	747374	312	252626	828715	454	171285	1341	142	8659	1
34	0	747562	312	252438	828987	454	171013	1426	142	8574	**56** 0
	1	747749	312	252251	829260	454	170740	1511	142	8489	59
	2	747936	312	252064	829532	454	170468	1596	142	8404	55 58
34	3	748123	311	251877	829805	454	170195	1682	142	8318	57
	4	748310	311	251690	830077	454	169923	1767	142	8233	56
	5	748497	311	251503	830349	453	169651	1853	142	8147	55
	6	748683	311	251317	830621	453	169379	1938	142	8062	54
	7	748870	311	251130	830893	453	169107	2024	143	7976	53
	8	749056	310	250944	831165	453	168835	2109	143	7891	52
	9	749243	310	250757	831437	453	168563	2195	143	7805	51
	10	749429	310	250571	831709	453	168291	2281	143	7719	50
	11	749615	310	250385	831981	453	168019	2366	143	7634	55 49
34	12	749801	310	250199	832253	453	167747	2452	143	7548	48
	13	749987	309	250013	832525	453	167475	2538	143	7462	47
	14	750172	309	249828	832796	453	167204	2624	143	7376	46
	15	750358	309	249642	833068	452	166932	2710	143	7290	45
	16	750543	309	249457	833339	452	166661	2796	143	7204	44
	17	750729	309	249271	833611	452	166389	2882	143	7118	43
	18	750914	308	249086	833882	452	166118	2968	144	7032	42
	19	751099	308	248901	834154	452	165846	3054	144	6946	41
	20	751284	308	248716	834425	452	165575	3141	144	6859	55 40
34	21	751469	308	248531	834696	452	165304	3227	144	6773	39
	22	751654	308	248346	834967	452	165033	3313	144	6687	38
	23	751839	308	248161	835238	452	164762	3400	144	6600	37
	24	752023	307	247977	835509	452	164491	3486	144	6514	36
	25	752208	307	247792	835780	451	164220	3573	144	6427	35
	26	752392	307	247608	836051	451	163949	3659	144	6341	34
	27	752576	307	247424	836322	451	163678	3746	144	6254	33
	28	752760	307	247240	836593	451	163407	3833	145	6167	32
	29	752944	306	247056	836864	451	163136	3919	145	6081	31
	30	753128		246872	837134		162866	4006		5994	**55** 30
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
56¼ Deg.											55¼ Deg.

34½ Deg.	TABLE V.—Log. Sines, etc.									35¼ Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9·		10·	9·		10·	10·08		9·91	
34 30	753128	306	246872	837134	451	162866	4006	145	5994	30
31	753312	306	246688	837405	451	162595	4093	145	5907	29
32	753495	306	246505	837675	451	162325	4180	145	5820	28
33	753679	306	246321	837946	451	162054	4267	145	5733	27
34	753862	305	246138	838216	451	161784	4354	145	5646	26
35	754046	305	245954	838487	450	161513	4441	145	5559	25
36	754229	305	245771	838757	450	161243	4528	145	5472	24
37	754412	305	245588	839027	450	160973	4615	145	5385	23
38	754595	305	245405	839297	450	160703	4703	145	5297	55 22
34 39	754778	304	245222	839568	450	160432	4790	145	5210	21
40	754960	304	245040	839838	450	160162	4877	146	5123	20
41	755143	304	244857	840108	450	159892	4965	146	5035	19
42	755326	304	244674	840378	450	159622	5052	146	4948	18
43	755508	304	244492	840647	450	159353	5140	146	4860	17
44	755690	304	244310	840917	449	159083	5227	146	4773	16
45	755872	303	244128	841187	449	158813	5315	146	4685	15
46	756054	303	243946	841457	449	158543	5402	146	4598	14
47	756236	303	243764	841726	449	158274	5490	146	4510	55 13
34 48	756418	303	243582	841996	449	158004	5578	146	4422	12
49	756600	303	243400	842266	449	157734	5666	146	4334	11
50	756782	302	243218	842535	449	157465	5754	147	4246	10
51	756963	302	243037	842805	449	157195	5842	147	4158	9
52	757144	302	242856	843074	449	156926	5930	147	4070	8
53	757326	302	242674	843343	449	156657	6018	147	3982	7
54	757507	302	242493	843612	449	156388	6106	147	3894	6
55	757688	302	242312	843882	448	156118	6194	147	3806	5
56	757869	301	242131	844151	448	155849	6282	147	3718	55 4
34 57	758050	301	241950	844420	448	155580	6370	147	3630	3
58	758230	301	241770	844689	448	155311	6459	147	3541	2
59	758411	301	241589	844958	448	155042	6547	147	3453	1
35 0	758591	301	241409	845227	448	154773	6635	147	3365	**55** 0
1	758772	300	241228	845496	448	154504	6724	147	3276	59
2	758952	300	241048	845764	448	154236	6813	148	3187	58
3	759132	300	240868	846033	448	153967	6901	148	3099	57
4	759312	300	240688	846302	448	153698	6990	148	3010	56
5	759492	300	240508	846570	447	153430	7078	148	2922	54 55
35 6	759672	299	240328	846839	447	153161	7167	148	2833	54
7	759852	299	240148	847107	447	152893	7256	148	2744	53
8	760031	299	239969	847376	447	152624	7345	148	2655	52
9	760211	299	239789	847644	447	152356	7434	148	2566	51
10	760390	299	239610	847913	447	152087	7523	148	2477	50
11	760569	298	239431	848181	447	151819	7612	148	2388	49
12	760748	298	239252	848449	447	151551	7701	149	2299	48
13	760927	298	239073	848717	447	151283	7790	149	2210	47
14	761106	298	238894	848986	447	151014	7879	149	2121	46
15	761285		238715	849254		150746	7969		2031	**54** 45
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
55¼ Deg.										54¾ Deg.

35¼ Deg.	TABLE V.—Log. Sines, etc.									36 Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9·7		10·2	9·		10·	10·0		9·9	
35 15	61285	298	38715	849254	447	150746	87969	149	12031	45
16	61464	298	38536	849522	447	150478	88058	149	11942	44
17	61642	298	38358	849790	446	150210	88147	149	11853	43
18	61821	297	38179	850058	446	149942	88237	149	11763	42
19	61999	297	38001	850325	446	149675	88326	149	11674	41
20	62177	297	37823	850593	446	149407	88416	149	11584	40
21	62356	297	37644	850861	446	149139	88505	149	11495	39
22	62534	296	37466	851129	446	148871	88595	149	11405	38
23	62712	296	37288	851396	446	148604	88685	150	11315	54 37
35 24	62889	296	37111	851664	446	148336	88774	150	11226	36
25	63067	296	36933	851931	446	148069	88864	150	11136	35
26	63245	296	36755	852199	446	147801	88954	150	11046	34
27	63422	296	36578	852466	446	147534	89044	150	10956	33
28	63600	295	36400	852733	445	147267	89134	150	10866	32
29	63777	295	36223	853001	445	146999	89224	150	10776	31
30	63954	295	36046	853268	445	146732	89314	150	10686	30
31	64131	295	35869	853535	445	146465	89404	150	10596	29
32	64308	295	35692	853802	445	146198	89494	150	10506	54 28
35 33	64485	294	35515	854069	445	145931	89585	150	10415	27
34	64662	294	35338	854336	445	145664	89675	151	10325	26
35	64838	294	35162	854603	445	145397	89765	151	10235	25
36	65015	294	34985	854870	445	145130	89856	151	10144	24
37	65191	294	34809	855137	445	144863	89946	151	10054	23
38	65367	294	34633	855404	445	144596	90037	151	09963	22
39	65544	293	34456	855671	444	144329	90127	151	09873	21
40	65720	293	34280	855938	444	144062	90218	151	09782	20
41	65896	293	34104	856204	444	143796	90309	151	09691	54 19
35 42	66072	293	33928	856471	444	143529	90399	151	09601	18
43	66247	293	33753	856737	444	143263	90490	151	09510	17
44	66423	293	33577	857004	444	142996	90581	151	09419	16
45	66598	292	33402	857270	444	142730	90672	152	09328	15
46	66774	292	33226	857537	444	142463	90763	152	09237	14
47	66949	292	33051	857803	444	142197	90854	152	09146	13
48	67124	292	32876	858069	444	141931	90945	152	09055	12
49	67300	292	32700	858336	444	141664	91036	152	08964	11
50	67475	291	32525	858602	443	141398	91127	152	08873	54 10
35 51	67649	291	32351	858868	443	141132	91219	152	08781	9
52	67824	291	32176	859134	443	140866	91310	152	08690	8
53	67999	291	32001	859400	443	140600	91401	152	08599	7
54	68173	291	31827	859666	443	140334	91493	152	08507	6
55	68348	290	31652	859932	443	140068	91584	153	08416	5
56	68522	290	31478	860198	443	139802	91676	153	08324	4
57	68697	290	31303	860464	443	139536	91767	153	08233	3
58	68871	290	31129	860730	443	139270	91859	153	08141	2
59	69045	290	30955	860995	443	139005	91951	153	08049	1
60	69219		30781	861261		138739	92042		07958	**54** 0
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
54¾ Deg.										54 Deg.

36 Deg.		TABLE V.—Log. Sines, etc.									36¾ Deg.
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·		10·	10·09		9·90	
36	0	769219	290	230781	861261	443	138739	2042	153	7958	60
	1	769393	289	230607	861527	443	138473	2134	153	7866	59
	2	769566	289	230434	861792	442	138208	2226	153	7774	58
	3	769740	289	230260	862058	442	137942	2318	153	7682	57
	4	769913	289	230087	862323	442	137677	2410	153	7590	56
	5	770087	289	229913	862589	442	137411	2502	153	7498	55
	6	770260	288	229740	862854	442	137146	2594	153	7406	54
	7	770433	288	229567	863119	442	136881	2686	154	7314	53
	8	770606	288	229394	863385	442	136615	2778	154	7222	53 52
36	9	770779	288	229221	863650	442	136350	2871	154	7129	51
	10	770952	288	229048	863915	442	136085	2963	154	7037	50
	11	771125	288	228875	864180	442	135820	3055	154	6945	49
	12	771298	287	228702	864445	442	135555	3148	154	6852	48
	13	771470	287	228530	864710	442	135290	3240	154	6760	47
	14	771643	287	228357	864975	442	135025	3333	154	6667	46
	15	771815	287	228185	865240	441	134760	3425	154	6575	45
	16	771987	287	228013	865505	441	134495	3518	154	6482	44
	17	772159	287	227841	865770	441	134230	3611	154	6389	53 43
36	18	772331	286	227669	866035	441	133965	3704	155	6296	42
	19	772503	286	227497	866300	441	133700	3796	155	6204	41
	20	772675	286	227325	866564	441	133436	3889	155	6111	40
	21	772847	286	227153	866829	441	133171	3982	155	6018	39
	22	773018	286	226982	867094	441	132906	4075	155	5925	38
	23	773190	286	226810	867358	441	132642	4168	155	5832	37
	24	773361	285	226639	867623	441	132377	4261	155	5739	36
	25	773533	285	226467	867887	441	132113	4355	155	5645	35
	26	773704	285	226296	868152	440	131848	4448	155	5552	53 34
36	27	773875	285	226125	868416	440	131584	4541	155	5459	33
	28	774046	285	225954	868680	440	131320	4634	156	5366	32
	29	774217	285	225783	868945	440	131055	4728	156	5272	31
	30	774388	284	225612	869209	440	130791	4821	156	5179	30
	31	774558	284	225442	869473	440	130527	4915	156	5085	29
	32	774729	284	225271	869737	440	130263	5008	156	4992	28
	33	774899	284	225101	870001	440	129999	5102	156	4898	27
	34	775070	284	224930	870265	440	129735	5196	156	4804	26
	35	775240	284	224760	870529	440	129471	5289	156	4711	53 25
36	36	775410	283	224590	870793	440	129207	5383	156	4617	24
	37	775580	283	224420	871057	440	128943	5477	156	4523	23
	38	775750	283	224250	871321	440	128679	5571	157	4429	22
	39	775920	283	224080	871585	440	128415	5665	157	4335	21
	40	776090	283	223910	871849	439	128151	5759	157	4241	20
	41	776259	283	223741	872112	439	127888	5853	157	4147	19
	42	776429	282	223571	872376	439	127624	5947	157	4053	18
	43	776598	282	223402	872640	439	127360	6041	157	3959	17
	44	776768	282	223232	872903	439	127097	6136	157	3864	16
	45	776937		223063	873167		126833	6230		3770	53 15
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
54 Deg.											53¼ Deg.

36¾ Deg.		TABLE V.—Log. Sines, etc.								37¼ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·7		10·2	9·8		10·1	10·		9·	
36	45	76937	282	23063	73167	439	26833	096230	157	903770	15
	46	77106	282	22894	73430	439	26570	096324	157	903676	14
	47	77275	281	22725	73694	439	26306	096419	157	903581	13
	48	77444	281	22556	73957	439	26043	096513	157	903487	12
	49	77613	281	22387	74220	439	25780	096608	158	903392	11
	50	77781	281	22219	74484	439	25516	096702	158	903298	10
	51	77950	281	22050	74747	439	25253	096797	158	903203	9
	52	78119	281	21881	75010	439	24990	096892	158	903108	8
	53	78287	280	21713	75273	438	24727	096986	158	903014	53 7
36	54	78455	280	21545	75536	438	24464	097081	158	902919	6
	55	78624	280	21376	75800	438	24200	097176	158	902824	5
	56	78792	280	21208	76063	438	23937	097271	158	902729	4
	57	78960	280	21040	76326	438	23674	097366	158	902634	3
	58	79128	280	20872	76589	438	23411	097461	159	902539	2
	59	79295	279	20705	76851	438	23149	097556	159	902444	1
37	0	79463	279	20537	77114	438	22886	097651	159	902349	**53** 0
	1	79631	279	20369	77377	438	22623	097747	159	902253	59
	2	79798	279	20202	77640	438	22360	097842	159	902158	52 58
37	3	79966	279	20034	77903	438	22097	097937	159	902063	57
	4	80133	279	19867	78165	438	21835	098033	159	901967	56
	5	80300	278	19700	78428	438	21572	098128	159	901872	55
	6	80467	278	19533	78691	438	21309	098224	159	901776	54
	7	80634	278	19366	78953	437	21047	098319	159	901681	53
	8	80801	278	19199	79216	437	20784	098415	159	901585	52
	9	80968	278	19032	79478	437	20522	098510	159	901490	51
	10	81134	278	18866	79741	437	20259	098606	160	901394	50
	11	81301	277	18699	80003	437	29997	098702	160	901298	52 49
37	12	81468	277	18532	80265	437	29735	098798	160	901202	48
	13	81634	277	18366	80528	437	19472	098894	160	901106	47
	14	81800	277	18200	80790	437	19210	098990	160	901010	46
	15	81966	277	18034	81052	437	18948	099086	160	900914	45
	16	82132	277	17868	81314	437	18686	099182	160	900818	44
	17	82298	276	17702	81576	437	18424	099278	160	900722	43
	18	82464	276	17536	81839	437	18161	099374	160	900626	42
	19	82630	276	17370	82101	437	17899	099471	160	900529	41
	20	82796	276	17204	82363	436	17637	099567	161	900433	52 40
37	21	82961	276	17039	82625	436	17375	099663	161	900337	39
	22	83127	276	16873	82887	436	17113	099760	161	900240	38
	23	83292	275	16708	83148	436	16852	099856	161	900144	37
	24	83458	275	16542	83410	436	16590	099953	161	900047	36
	25	83623	275	16377	83672	436	16328	100049	161	899951	35
	26	83788	275	16212	83934	436	16066	100146	161	899854	34
	27	83953	275	16047	84196	436	15804	100243	161	899757	33
	28	84118	275	15882	84457	436	15543	100340	161	899660	32
	29	84282	274	15718	84719	436	15281	100436	161	899564	31
	30	84447		15553	84980		15020	100533		899467	**52** 30
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
53¼ Deg.											52¾ Deg.

37½ Deg.	TABLE V.—Log. Sines, etc.									38¼ Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9·		10·	9·		10·	10·10		9·89	
37 30	784447	274	215553	884980	436	115020	0533	162	9467	30
31	784612	274	215388	885242	436	114758	0630	162	9370	29
32	784776	274	215224	885503	436	114497	0727	162	9273	28
33	784941	274	215059	885765	436	114235	0824	162	9176	27
34	785105	274	214895	886026	436	113974	0922	162	9078	26
35	785269	273	214731	886288	436	113712	1019	162	8981	25
36	785433	273	214567	886549	435	113451	1116	162	8884	24
37	785597	273	214403	886810	435	113190	1213	162	8787	23
38	785761	273	214239	887072	435	112928	1311	162	8689	52 22
37 39	785925	273	214075	887333	435	112667	1408	162	8592	21
40	786089	273	213911	887594	435	112406	1506	163	8494	20
41	786252	272	213748	887855	435	112145	1603	163	8397	19
42	786416	272	213584	888116	435	111884	1701	163	8299	18
43	786579	272	213421	888377	435	111623	1798	163	8202	17
44	786742	272	213258	888639	435	111361	1896	163	8104	16
45	786906	272	213094	888900	435	111100	1994	163	8006	15
46	787069	272	212931	889160	435	110840	2092	163	7908	14
47	787232	271	212768	889421	435	110579	2190	163	7810	52 13
37 48	787395	271	212605	889682	435	110318	2288	163	7712	12
49	787557	271	212443	889943	435	110057	2386	163	7614	11
50	787720	271	212280	890204	434	109796	2484	163	7516	10
51	787883	271	212117	890465	434	109535	2582	164	7418	9
52	788045	271	211955	890725	434	109275	2680	164	7320	8
53	788208	271	211792	890986	434	109014	2778	164	7222	7
54	788370	271	211630	891247	434	108753	2877	164	7123	6
55	788532	270	211468	891507	434	108493	2975	164	7025	5
56	788694	270	211306	891768	434	108232	3074	164	6926	52 4
37 57	788856	270	211144	892028	434	107972	3172	164	6828	3
58	789018	270	210982	892289	434	107711	3271	164	6729	2
59	789180	270	210820	892549	434	107451	3369	164	6631	1
38 0	789342	269	210658	892810	434	107190	3468	164	6532	52 0
1	789504	269	210496	893070	434	106930	3567	165	6433	59
2	789665	269	210335	893331	434	106669	3665	165	6335	58
3	789827	269	210173	893591	434	106409	3764	165	6236	57
4	789988	269	210012	893851	434	106149	3863	165	6137	56
5	790149	269	209851	894111	434	105889	3962	165	6038	51 55
38 6	790310	268	209690	894371	434	105629	4061	165	5939	54
7	790471	268	209529	894632	433	105368	4160	165	5840	53
8	790632	268	209368	894892	433	105108	4259	165	5741	52
9	790793	268	209207	895152	433	104848	4359	165	5641	51
10	790954	268	209046	895412	433	104588	4458	165	5542	50
11	791115	268	208885	895672	433	104328	4557	166	5443	49
12	791275	267	208725	895932	433	104068	4657	166	5343	48
13	791436	267	208564	896192	433	103808	4756	166	5244	47
14	791596	267	208404	896452	433	103548	4855	166	5145	46
15	791757		208243	896712		103288	4955		5045	51 45
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
52½ Deg.										51¾ Deg.

38¼ Deg.	TABLE V.—Log. Sines, etc.									39 Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9·		10·	9·		10·	10·10		9·89	
38 15	791757	267	208243	896712	433	103288	4955	166	5045	45
16	791917	267	208083	896971	433	103029	5055	166	4945	44
17	792077	267	207923	897231	433	102769	5154	166	4846	43
18	792237	266	207763	897491	433	102509	5254	166	4746	42
19	792397	266	207603	897751	433	102249	5354	166	4646	41
20	792557	266	207443	898010	433	101990	5454	166	4546	40
21	792716	266	207284	898270	433	101730	5554	167	4446	39
22	792876	266	207124	898530	433	101470	5654	167	4346	38
23	793035	266	206965	898789	433	101211	5754	167	4246	51 37
38 24	793195	265	206805	899049	432	100951	5854	167	4146	36
25	793354	265	206646	899308	432	100692	5954	167	4046	35
26	793514	265	206486	899568	432	100432	6054	167	3946	34
27	793673	265	206327	899827	432	100173	6154	167	3846	33
28	793832	265	206168	900086	432	099914	6255	167	3745	32
29	793991	265	206009	900346	432	099654	6355	167	3645	31
30	794150	264	205850	900605	432	099395	6456	167	3544	30
31	794308	264	205692	900864	432	099136	6556	168	3444	29
32	794467	264	205533	901124	432	098876	6657	168	3343	51 28
38 33	794626	264	205374	901383	432	098617	6757	168	3243	27
34	794784	264	205216	901642	432	098358	6858	168	3142	26
35	794942	264	205058	901901	432	098099	6959	168	3041	25
36	795101	264	204899	902160	432	097840	7060	168	2940	24
37	795259	263	204741	902419	432	097581	7161	168	2839	23
38	795417	263	204583	902679	432	097321	7261	168	2739	22
39	795575	263	204425	902938	432	097062	7362	168	2638	21
40	795733	263	204267	903197	431	096803	7464	168	2536	20
41	795891	263	204109	903455	431	096545	7565	169	2435	51 19
38 42	796049	263	203951	903714	431	096286	7666	169	2334	18
43	796206	263	203794	903973	431	096027	7767	169	2233	17
44	796364	262	203636	904232	431	095768	7868	169	2132	16
45	796521	262	203479	904491	431	095509	7970	169	2030	15
46	796679	262	203321	904750	431	095250	8071	169	1929	14
47	796836	262	203164	905008	431	094992	8173	169	1827	13
48	796993	262	203007	905267	431	094733	8274	169	1726	12
49	797150	261	202850	905526	431	094474	8376	169	1624	11
50	797307	261	202693	905784	431	094216	8477	170	1523	51 10
38 51	797464	261	202536	906043	431	093957	8579	170	1421	9
52	797621	261	202379	906302	431	093698	8681	170	1319	8
53	797777	261	202223	906560	431	093440	8783	170	1217	7
54	797934	261	202066	906819	431	093181	8885	170	1115	6
55	798091	261	201909	907077	431	092923	8987	170	1013	5
56	798247	261	201753	907336	431	092664	9089	170	0911	4
57	798403	260	201597	907594	431	092406	9191	170	0809	3
58	798560	260	201440	907852	431	092148	9293	170	0707	2
59	798716	260	201284	908111	430	091889	9395	170	0605	1
60	798872		201128	908369		091631	9497		0503	**51** 0
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
51¾ Deg.										51 Deg.

39 Deg.		TABLE V.—Log. Sines, etc.									39¾ Deg.
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·		10·	9·9		10·0	10·1		9·8	
39	0	798872	260	201128	08369	430	91631	09497	170	90503	60
	1	799028	260	200972	08628	430	91372	09600	171	90400	59
	2	799184	260	200816	08886	430	91114	09702	171	90298	58
	3	799339	259	200661	09144	430	90856	09805	171	90195	57
	4	799495	259	200505	09402	430	90598	09907	171	90093	56
	5	799651	259	200349	09660	430	90340	10010	171	89990	55
	6	799806	259	200194	09918	430	90082	10112	171	89888	54
	7	799962	259	200038	10177	430	89823	10215	171	89785	53
	8	800117	259	199883	10435	430	89565	10318	171	89682	50 52
39	9	800272	258	199728	10693	430	89307	10421	171	89579	51
	10	800427	258	199573	10951	430	89049	10523	171	89477	50
	11	800582	258	199418	11209	430	88791	10626	172	89374	49
	12	800737	258	199263	11467	430	88533	10729	172	89271	48
	13	800892	258	199108	11724	430	88276	10832	172	89168	47
	14	801047	258	198953	11982	430	88018	10936	172	89064	46
	15	801201	258	198799	12240	430	87760	11039	172	88961	45
	16	801356	257	198644	12498	430	87502	11142	172	88858	44
	17	801511	257	198489	12756	430	87244	11245	172	88755	50 43
39	18	801665	257	198335	13014	429	86986	11349	172	88651	42
	19	801819	257	198181	13271	429	86729	11452	172	88548	41
	20	801973	257	198027	13529	429	86471	11556	173	88444	40
	21	802128	257	197872	13787	429	86213	11659	173	88341	39
	22	802282	256	197718	14044	429	85956	11763	173	88237	38
	23	802436	256	197564	14302	429	85698	11866	173	88134	37
	24	802589	256	197411	14560	429	85440	11970	173	88030	36
	25	802743	256	197257	14817	429	85183	12074	173	87926	35
	26	802897	256	197103	15075	429	84925	12178	173	87822	50 34
39	27	803050	256	196950	15332	429	84668	12282	173	87718	33
	28	803204	256	196796	15590	429	84410	12386	173	87614	32
	29	803357	255	196643	15847	429	84153	12490	173	87510	31
	30	803511	255	196489	16104	429	83896	12594	174	87406	30
	31	803664	255	196336	16362	429	83638	12698	174	87302	29
	32	803817	255	196183	16619	429	83381	12802	174	87198	28
	33	803970	255	196030	16877	429	83123	12907	174	87093	27
	34	804123	255	195877	17134	429	82866	13011	174	86989	26
	35	804276	254	195724	17391	429	82609	13115	174	86885	50 25
39	36	804428	254	195572	17648	429	82352	13220	174	86780	24
	37	804581	254	195419	17905	429	82095	13324	174	86676	23
	38	804734	254	195266	18163	428	81837	13429	174	86571	22
	39	804886	254	195114	18420	428	81580	13534	174	86466	21
	40	805039	254	194961	18677	428	81323	13638	174	86362	20
	41	805191	254	194809	18934	428	81066	13743	175	86257	19
	42	805343	254	194657	19191	428	80809	13848	175	86152	18
	43	805495	253	194505	19448	428	80552	13953	175	86047	17
	44	805647	253	194353	19705	428	80295	14058	175	85942	16
	45	805799	253	194201	19962	428	80038	14163	175	85837	50 15
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
51 Deg.											50¼ Deg.

39¾ Deg		TABLE V.—Log. Sines, etc.								40¼ Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9·		10·	9·		10·	10·11		9·88	
39 45	805799	253	194201	919962	428	080038	4163	175	5837	15
46	805951	253	194049	920219	428	079781	4268	175	5732	14
47	806103	253	193897	920476	428	079524	4373	175	5627	13
48	806254	253	193746	920733	428	079267	4478	175	5522	12
49	806406	252	193594	920990	428	079010	4584	175	5416	11
50	806557	252	193443	921247	428	078753	4689	176	5311	10
51	806709	252	193291	921503	428	078497	4795	176	5205	9
52	806860	252	193140	921760	428	078240	4900	176	5100	8
53	807011	252	192989	922017	428	077983	5006	176	4994	50 7
39 54	807163	252	192837	922274	428	077726	5111	176	4889	6
55	807314	252	192686	922530	428	077470	5217	176	4783	5
56	807465	251	192535	922787	428	077213	5323	176	4677	4
57	807615	251	192385	923044	428	076956	5428	176	4572	3
58	807766	251	192234	923300	428	076700	5534	176	4466	2
59	807917	251	192083	923557	427	076443	5640	176	4360	1
40 0	808067	251	191933	923813	427	076187	5746	177	4254	**50** 0
1	808218	251	191782	924070	427	075930	5852	177	4148	59
2	808368	251	191632	924327	427	075673	5958	177	4042	49 58
40 3	808519	250	191481	924583	427	075417	6064	177	3936	57
4	808669	250	191331	924840	427	075160	6171	177	3829	56
5	808819	250	191181	925096	427	074904	6277	177	3723	55
6	808969	250	191031	925352	427	074648	6383	177	3617	54
7	809119	250	190881	925609	427	074391	6490	177	3510	53
8	809269	250	190731	925865	427	074135	6596	177	3404	52
9	809419	249	190581	926122	427	073878	6703	178	3297	51
10	809569	249	190431	926378	427	073622	6809	178	3191	50
11	809718	249	190282	926634	427	073366	6916	178	3084	49 49
40 12	809868	249	190132	926890	427	073110	7023	178	2977	48
13	810017	249	189983	927147	427	072853	7129	178	2871	47
14	810167	249	189833	927403	427	072597	7236	178	2764	46
15	810316	248	189684	927659	427	072341	7343	178	2657	45
16	810465	248	189535	927915	427	072085	7450	178	2550	44
17	810614	248	189386	928171	427	071829	7557	178	2443	43
18	810763	248	189237	928427	427	071573	7664	179	2336	42
19	810912	248	189088	928683	427	071317	7771	179	2229	41
20	811061	248	188939	928940	427	071060	7879	179	2121	49 40
40 21	811210	248	188790	929196	427	070804	7986	179	2014	39
22	811358	247	188642	929452	427	070548	8093	179	1907	38
23	811507	247	188493	929708	427	070292	8201	179	1799	37
24	811655	247	188345	929964	426	070036	8308	179	1692	36
25	811804	247	188196	930220	426	069780	8416	179	1584	35
26	811952	247	188048	930475	426	069525	8523	179	1477	34
27	812100	247	187900	930731	426	069269	8631	179	1369	33
28	812248	247	187752	930987	426	069013	8739	180	1261	32
29	812396	246	187604	931243	426	068757	8847	180	1153	31
30	812544		187456	931499		068501	8954		1046	**49** 30
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
50¼ Deg.										49½ Deg.

40½ Deg.	TABLE V.—Log. Sines, etc.									41½ Deg.
° ′	Sine.	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9·8		10·1	9·		10·	10·1		9·8	
40 30	12544	246	87456	931499	426	068501	18954	180	81046	30
31	12692	246	87308	931755	426	068245	19062	180	80938	29
32	12840	246	87160	932010	426	067990	19170	180	80830	28
33	12988	246	87012	932266	426	067734	19278	180	80722	27
34	13135	246	86865	932522	426	067478	19387	180	80613	26
35	13283	246	86717	932778	426	067222	19495	180	80505	25
36	13430	245	86570	933033	426	066967	19603	180	80397	24
37	13578	245	86422	933289	426	066711	19711	181	80289	23
38	13725	245	86275	933545	426	066455	19820	181	80180	49 22
40 39	13872	245	86128	933800	426	066200	19928	181	80072	21
40	14019	245	85981	934056	426	065944	20037	181	79963	20
41	14166	245	85834	934311	426	065689	20145	181	79855	19
42	14313	245	85687	934567	426	065433	20254	181	79746	18
43	14460	244	85540	934823	426	065177	20363	181	79637	17
44	14607	244	85393	935078	426	064922	20471	181	79529	16
45	14753	244	85247	935333	426	064667	20580	181	79420	15
46	14900	244	85100	935589	426	064411	20689	181	79311	14
47	15046	244	84954	935844	426	064156	20798	182	79202	49 13
40 48	15193	244	84807	936100	426	063900	20907	182	79093	12
49	15339	244	84661	936355	426	063645	21016	182	78984	11
50	15485	243	84515	936610	426	063390	21125	182	78875	10
51	15632	243	84368	936866	425	063134	21234	182	78766	9
52	15778	243	84222	937121	425	062879	21344	182	78656	8
53	15924	243	84076	937376	425	062624	21453	182	78547	7
54	16069	243	83931	937632	425	062368	21562	182	78438	6
55	16215	243	83785	937887	425	062113	21672	182	78328	5
56	16361	243	83639	938142	425	061858	21781	183	78219	49 4
40 57	16507	242	83493	938398	425	061602	21891	183	78109	3
58	16652	242	83348	938653	425	061347	22001	183	77999	2
59	16798	242	83202	938908	425	061092	22110	183	77890	1
41 0	16943	242	83057	939163	425	060837	22220	183	77780	49 0
1	17088	242	82912	939418	425	060582	22330	183	77670	59
2	17233	242	82767	939673	425	060327	22440	183	77560	58
3	17379	242	82621	939928	425	060072	22550	183	77450	57
4	17524	241	82476	940183	425	059817	22660	183	77340	56
5	17668	241	82332	940438	425	059562	22770	184	77230	48 55
41 6	17813	241	82187	940694	425	059306	22880	184	77120	54
7	17958	241	82042	940949	425	059051	22990	184	77010	53
8	18103	241	81897	941204	425	058796	23101	184	76899	52
9	18247	241	81753	941458	425	058542	23211	184	76789	51
10	18392	241	81608	941714	425	058286	23322	184	76678	50
11	18536	240	81464	941968	425	058032	23432	184	76568	49
12	18681	240	81319	942223	425	057777	23543	184	76457	48
13	18825	240	81175	942478	425	057522	23653	184	76347	47
14	18969	240	81031	942733	425	057267	23764	184	76236	46
15	19113	240	80887	942988	425	057012	23875	185	76125	48 45
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
49½ Deg.										48¾ Deg.

41¼ Deg.	TABLE V.—Log. Sines, etc.									42 Deg.
° ′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
	9·		10·	9·		10·	10·12		9·87	
41 15	819113	240	180887	942988	425	057012	3875	185	6125	45
16	819257	240	180743	943243	425	056757	3986	185	6014	44
17	819401	240	180599	943498	425	056502	4096	185	5904	43
18	819545	239	180455	943752	425	056248	4207	185	5793	42
19	819689	239	180311	944007	425	055993	4318	185	5682	41
20	819832	239	180168	944262	425	055738	4429	185	5571	40
21	819976	239	180024	944517	425	055483	4541	185	5459	39
22	820120	239	179880	944771	424	055229	4652	185	5348	38
23	820263	239	179737	945026	424	054974	4763	185	5237	48 37
41 24	820406	239	179594	945281	424	054719	4874	186	5126	36
25	820550	238	179450	945535	424	054465	4986	186	5014	35
26	820693	238	179307	945790	424	054210	5097	186	4903	34
27	820836	238	179164	946045	424	053955	5209	186	4791	33
28	820979	238	179021	946299	424	053701	5320	186	4680	32
29	821122	238	178878	946554	424	053446	5432	186	4568	31
30	821265	238	178735	946808	424	053192	5544	186	4456	30
31	821407	238	178593	947063	424	052937	5656	186	4344	29
32	821550	238	178450	947318	424	052682	5768	187	4232	48 28
41 33	821693	237	178307	947572	424	052428	5879	187	4121	27
34	821835	237	178165	947826	424	052174	5991	187	4009	26
35	821977	237	178023	948081	424	051919	6104	187	3896	25
36	822120	237	177880	948336	424	051664	6216	187	3784	24
37	822262	237	177738	948590	424	051410	6328	187	3672	23
38	822404	237	177596	948844	424	051156	6440	187	3560	22
39	822546	237	177454	949099	424	050901	6552	187	3448	21
40	822688	236	177312	949353	424	050647	6665	187	3335	20
41	822830	236	177170	949607	424	050393	6777	187	3223	48 19
41 42	822972	236	177028	949862	424	050138	6890	188	3110	18
43	823114	236	176886	950116	424	049884	7002	188	2998	17
44	823255	236	176745	950370	424	049630	7115	188	2885	16
45	823397	236	176603	950625	424	049375	7228	188	2772	15
46	823539	236	176461	950879	424	049121	7341	188	2659	14
47	823680	235	176320	951133	424	048867	7453	188	2547	13
48	823821	235	176179	951388	424	048612	7566	188	2434	12
49	823963	235	176037	951642	424	048358	7679	188	2321	11
50	824104	235	175896	951896	424	048104	7792	188	2208	48 10
41 51	824245	235	175755	952150	424	047850	7905	189	2095	9
52	824386	235	175614	952405	424	047595	8019	189	1981	8
53	824527	235	175473	952659	424	047341	8132	189	1868	7
54	824668	234	175332	952913	424	047087	8245	189	1755	6
55	824808	234	175192	953167	423	046833	8359	189	1641	5
56	824949	234	175051	953421	423	046579	8472	189	1528	4
57	825090	234	174910	953675	423	046325	8586	189	1414	3
58	825230	234	174770	953929	423	046071	8699	189	1301	2
59	825371	234	174629	954183	423	045817	8813	189	1187	1
60	825511	234	174489	954437	423	045563	8927	189	1073	48 0
	Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
48¾ Deg.										48 Deg.

42 Deg.		TABLE V.—Log. Sines, etc.									42¾ Deg.
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·8		10·1	9·9		10·0	10·1		9·8	
42	0	25511	234	74489	54437	423	45563	28927	190	71073	60
	1	25651	233	74349	54691	423	45309	29040	190	70960	59
	2	25791	233	74209	54945	423	45055	29154	190	70846	58
	3	25931	233	74069	55200	423	44800	29268	190	70732	57
	4	26071	233	73929	55454	423	44546	29382	190	70618	56
	5	26211	233	73789	55707	423	44293	29496	190	70504	55
	6	26351	233	73649	55961	423	44039	29610	190	70390	54
	7	26491	233	73509	56215	423	43785	29724	190	70276	53
	8	26631	233	73369	56469	423	43531	29839	190	70161	47 52
42	9	26770	232	73230	56723	423	43277	29953	191	70047	51
	10	26910	232	73090	56977	423	43023	30067	191	69933	50
	11	27049	232	72951	57231	423	42769	30182	191	69818	49
	12	27189	232	72811	57485	423	42515	30296	191	69704	48
	13	27328	232	72672	57739	423	42261	30411	191	69589	47
	14	27467	232	72533	57993	423	42007	30526	191	69474	46
	15	27606	232	72394	58246	423	41754	30640	191	69360	45
	16	27745	232	72255	58500	423	41500	30755	191	69245	44
	17	27884	231	72116	58754	423	41246	30870	191	69130	47 43
42	18	28023	231	71977	59008	423	40992	30985	192	69015	42
	19	28162	231	71838	59262	423	40738	31100	192	68900	41
	20	28301	231	71699	59516	423	40484	31215	192	68785	40
	21	28439	231	71561	59769	423	40231	31330	192	68670	39
	22	28578	231	71422	60023	423	39977	31445	192	68555	38
	23	28716	231	71284	60277	423	39723	31560	192	68440	37
	24	28855	230	71145	60531	423	39469	31676	192	68324	36
	25	28993	230	71007	60784	423	39216	31791	192	68209	35
	26	29131	230	70869	61038	423	38962	31907	192	68093	47 34
42	27	29269	230	70731	61291	423	38709	32022	193	67978	33
	28	29407	230	70593	61545	423	38455	32138	193	67862	32
	29	29545	230	70455	61799	423	38201	32253	193	67747	31
	30	29683	230	70317	62052	423	37948	32369	193	67631	30
	31	29821	229	70179	62306	423	37694	32485	193	67515	29
	32	29959	229	70041	62560	423	37440	32601	193	67399	28
	33	30097	229	69903	62813	423	37187	32717	193	67283	27
	34	30234	229	69766	63067	423	36933	32833	193	67167	26
	35	30372	229	69628	63320	423	36680	32949	193	67051	47 25
42	36	30509	229	69491	63574	423	36426	33065	194	66935	24
	37	30646	229	69354	63827	423	36173	33181	194	66819	23
	38	30784	229	69216	64081	423	35919	33297	194	66703	22
	39	30921	228	69079	64335	423	35665	33414	194	66586	21
	40	31058	228	68942	64588	422	35412	33530	194	66470	20
	41	31195	228	68805	64842	422	35158	33647	194	66353	19
	42	31332	228	68668	65095	422	34905	33763	194	66237	18
	43	31469	228	68531	65349	422	34651	33880	194	66120	17
	44	31606	228	68394	65602	422	34398	33996	194	66004	16
	45	31742		68258	65855		34145	34113	195	65887	47 15
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
48 Deg.											47¼ Deg.

42¾ Deg.		TABLE V.—Log. Sines, etc.								43¼ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·8		10·1	9·9		10·0	10·1		9·8	
42	45	31742	228	68258	65855	422	34145	34113	195	65887	15
	46	31879	228	68121	66109	422	33891	34230	195	65770	14
	47	32015	227	67985	66362	422	33638	34347	195	65653	13
	48	32152	227	67848	66616	422	33384	34464	195	65536	12
	49	32288	227	67712	66869	422	33131	34581	195	65419	11
	50	32425	227	67575	67123	422	32877	34698	195	65302	10
	51	32561	227	67439	67376	422	32624	34815	195	65185	9
	52	32697	227	67303	67629	422	32371	34932	195	65068	8
	53	32833	227	67167	67883	422	32117	35050	195	64950	47 7
42	54	32969	226	67031	68136	422	31864	35167	196	64833	6
	55	33105	226	66895	68389	422	31611	35284	196	64716	5
	56	33241	226	66759	68643	422	31357	35402	196	64598	4
	57	33377	226	66623	68896	422	31104	35519	196	64481	3
	58	33512	226	66488	69149	422	30851	35637	196	64363	2
	59	33648	226	66352	69403	422	30597	35755	196	64245	1
43	0	33783	226	66217	69656	422	30344	35873	196	64127	**47** 0
	1	33919	225	66081	69909	422	30091	35990	196	64010	59
	2	34054	225	65946	70162	422	29838	36108	197	63892	46 58
43	3	34189	225	65811	70416	422	29584	36226	197	63774	57
	4	34325	225	65675	70669	422	29331	36344	197	63656	56
	5	34460	225	65540	70922	422	29078	36462	197	63538	55
	6	34595	225	65405	71175	422	28825	36581	197	63419	54
	7	34730	225	65270	71429	422	28571	36699	197	63301	53
	8	34865	225	65135	71682	422	28318	36817	197	63183	52
	9	34999	224	65001	71935	422	28065	36936	197	63064	51
	10	35134	224	64866	72188	422	27812	37054	198	62946	50
	11	35269	224	64731	72441	422	27559	37173	198	62827	46 49
43	12	35403	224	64597	72694	422	27306	37291	198	62709	48
	13	35538	224	64462	72948	422	27052	37410	198	62590	47
	14	35672	224	64328	73201	422	26799	37529	198	62471	46
	15	35807	224	64193	73454	422	26546	37647	198	62353	45
	16	35941	224	64059	73707	422	26293	37766	198	62234	44
	17	36075	223	63925	73960	422	26040	37885	198	62115	43
	18	36209	223	63791	74213	422	25787	38004	198	61996	42
	19	36343	223	63657	74466	422	25534	38123	198	61877	41
	20	36477	223	63523	74719	422	25281	38242	199	61758	46 40
43	21	36611	223	63389	74973	422	25027	38362	199	61638	39
	22	36745	223	63255	75226	422	24774	38481	199	61519	38
	23	36878	223	63122	75479	422	24521	38600	199	61400	37
	24	37012	222	62988	75732	422	24268	38720	199	61280	36
	25	37146	222	62854	75985	422	24015	38839	199	61161	35
	26	37279	222	62721	76238	422	23762	38959	199	61041	34
	27	37412	222	62588	76491	422	23509	39078	199	60922	33
	28	37546	222	62454	76744	422	23256	39198	199	60802	32
	29	37679	222	62321	76997	422	23003	39318	199	60682	31
	30	37812		62188	77250		22750	39438	200	60562	**46** 30
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
47¼ Deg.										46¾ Deg.	

43½ Deg.		TABLE V.—Log. Sines, etc.								44½ Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·8		10·1	9·9		10·0	10·1		9·8	
43	30	37812	222	62188	77250	422	22750	39438	200	60562	30
	31	37945	222	62055	77503	422	22497	39558	200	60442	29
	32	38078	221	61922	77756	422	22244	39678	200	60322	28
	33	38211	221	61789	78009	422	21991	39798	200	60202	27
	34	38344	221	61656	78262	422	21738	39918	200	60082	26
	35	38477	221	61523	78515	422	21485	40038	200	59962	25
	36	38610	221	61390	78768	422	21232	40158	200	59842	24
	37	38742	221	61258	79021	422	20979	40279	201	59721	23
	38	38875	221	61125	79274	422	20726	40399	201	59601	46 22
46	39	39007	221	60993	79527	422	20473	40520	201	59480	21
	40	39140	220	60860	79780	422	20220	40640	201	59360	20
	41	39272	220	60728	80033	422	19967	40761	201	59239	19
	42	39404	220	60596	80286	422	19714	40881	201	59119	18
	43	39536	220	60464	80538	422	19462	41002	201	58998	17
	44	39668	220	60332	80791	422	19209	41123	201	58877	16
	45	39800	220	60200	81044	421	18956	41244	201	58756	15
	46	39932	220	60068	81297	421	18703	41365	202	58635	14
	47	40064	219	59936	81550	421	18450	41486	202	58514	46 13
43	48	40196	219	59804	81803	421	18197	41607	202	58393	12
	49	40328	219	59672	82056	421	17944	41728	202	58272	11
	50	40459	219	59541	82309	421	17691	41849	202	58151	10
	51	40591	219	59409	82562	421	17438	41971	202	58029	9
	52	40722	219	59278	82814	421	17186	42092	202	57908	8
	53	40854	219	59146	83067	421	16933	42214	202	57786	7
	54	40985	219	59015	83320	421	16680	42335	203	57665	6
	55	41116	218	58884	83573	421	16427	42457	203	57543	5
	56	41247	218	58753	83826	421	16174	42578	203	57422	46 4
43	57	41378	218	58622	84079	421	15921	42700	203	57300	3
	58	41509	218	58491	84331	421	15669	42822	203	57178	2
	59	41640	218	58360	84584	421	15416	42944	203	57056	1
44	0	41771	218	58229	84837	421	15163	43066	203	56934	46 0
	1	41902	218	58098	85090	421	14910	43188	203	56812	59
	2	42033	218	57967	85343	421	14657	43310	204	56690	58
	3	42163	217	57837	85596	421	14404	43432	204	56568	57
	4	42294	217	57706	85848	421	14152	43554	204	56446	56
	5	42424	217	57576	86101	421	13899	43677	204	56323	45 55
44	6	42555	217	57445	86354	421	13646	43799	204	56201	54
	7	42685	217	57315	86607	421	13393	43922	204	56078	53
	8	42815	217	57185	86860	421	13140	44044	204	55956	52
	9	42946	217	57054	87112	421	12888	44167	204	55833	51
	10	43076	217	56924	87365	421	12635	44289	205	55711	50
	11	43206	216	56794	87618	421	12382	44412	205	55588	49
	12	43336	216	56664	87871	421	12129	44535	205	55465	48
	13	43466	216	56534	88123	421	11877	44658	205	55342	47
	14	43595	216	56405	88376	421	11624	44781	205	55219	46
	15	43725		56275	88629		11371	44904		55096	45 45
		Cos.	D.	Sec.	Cot.	D	Tang.	Cos.	D.	Sine	° ′
46½ Deg.											45¾ Deg.

44¼ Deg.		TABLE V.—Log. Sines, etc.								45 Deg.	
°	′	Sine	D.	Cosec.	Tang.	D.	Cot.	Sec.	D.	Cos.	
		9·84		10·1			10·0	10·1		9·8	
44	15	3725	216	56275	9·988629	421	11371	44904	205	55096	45
	16	3855	216	56145	9·988882	421	11118	45027	205	54973	44
	17	3984	216	56016	9·989134	421	10866	45150	205	54850	43
	18	4114	215	55886	9·989387	421	10613	45273	206	54727	42
	19	4243	215	55757	9·989640	421	10360	45397	206	54603	41
	20	4372	215	55628	9·989893	421	10107	45520	206	54480	40
	21	4502	215	55498	9·990145	421	09855	45644	206	54356	39
	22	4631	215	55369	9·990398	421	09602	45767	206	54233	38
	23	4760	215	55240	9·990651	421	09349	45891	206	54109	45 37
44	24	4889	215	55111	9·990903	421	09097	46014	206	53986	36
	25	5018	215	54982	9·991156	421	08844	46138	206	53862	35
	26	5147	215	54853	9·991409	421	08591	46262	206	53738	34
	27	5276	214	54724	9·991662	421	08338	46386	207	53614	33
	28	5405	214	54595	9·991914	421	08086	46510	207	53490	32
	29	5533	214	54467	9·992167	421	07833	46634	207	53366	31
	30	5662	214	54338	9·992420	421	07580	46758	207	53242	30
	31	5790	214	54210	9·992672	421	07328	46882	207	53118	29
	32	5919	214	54081	9·992925	421	07075	47006	207	52994	45 28
44	33	6047	214	53953	9·993178	421	06822	47131	207	52869	27
	34	6175	214	53825	9·993430	421	06570	47255	207	52745	26
	35	6304	214	53696	9·993683	421	06317	47380	207	52620	25
	36	6432	213	53568	9·993936	421	06064	47504	208	52496	24
	37	6560	213	53440	9·994189	421	05811	47629	208	52371	23
	38	6688	213	53312	9·994441	421	05559	47753	208	52247	22
	39	6816	213	53184	9·994694	421	05306	47878	208	52122	21
	40	6944	213	53056	9·994947	421	05053	48003	208	51997	20
	41	7071	213	52929	9·995199	421	04801	48128	208	51872	45 19
44	42	7199	213	52801	9·995452	421	04548	48253	208	51747	18
	43	7327	213	52673	9·995705	421	04295	48378	208	51622	17
	44	7454	212	52546	9·995957	421	04043	48503	209	51497	16
	45	7582	212	52418	9·996210	421	03790	48628	209	51372	15
	46	7709	212	52291	9·996463	421	03537	48754	209	51246	14
	47	7836	212	52164	9·996715	421	03285	48879	209	51121	13
	48	7964	212	52036	9·996968	421	03032	49004	209	50996	12
	49	8091	212	51909	9·997221	421	02779	49130	209	50870	11
	50	8218	212	51782	9·997473	421	02527	49255	209	50745	45 10
44	51	8345	212	51655	9·997726	421	02274	49381	209	50619	9
	52	8472	211	51528	9·997979	421	02021	49507	210	50493	8
	53	8599	211	51401	9·998231	421	01769	49632	210	50368	7
	54	8726	211	51274	9·998484	421	01516	49758	210	50242	6
	55	8852	211	51148	9·998737	421	01263	49884	210	50116	5
	56	8979	211	51021	9·998989	421	01011	50010	210	49990	4
	57	9106	211	50894	9·999242	421	00758	50136	210	49864	3
	58	9232	211	50768	9·999495	421	00505	50262	210	49738	2
	59	9359	211	50641	9·999747	421	00253	50389	210	49611	1
	60	9485		50515	10.000000		00000	50515		49485	**45** 0
		Cos.	D.	Sec.	Cot.	D.	Tang.	Cos.	D.	Sine	° ′
45¾ Deg.											45 Deg.

TABLE VI.—Meridional Parts.

′	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	′
0	0	60	120	180	240	300	361	421	482	542	603	664	725	787	848	910	973	1035	1098	1161	1225	1289	1354	1419	1484	0
1	1	61	121	181	241	301	362	422	483	543	604	665	726	788	850	911	974	1036	1099	1163	1226	1290	1355	1420	1485	1
2	2	62	122	182	242	302	363	423	484	544	605	666	727	789	851	913	975	1037	1100	1164	1227	1291	1356	1421	1486	2
3	3	63	123	183	243	303	364	424	485	545	606	667	728	790	852	914	976	1038	1101	1165	1228	1292	1357	1422	1487	3
4	4	64	124	184	244	304	365	425	486	546	607	668	729	791	853	915	977	1039	1102	1166	1229	1293	1358	1423	1488	4
5	5	65	125	185	245	305	366	426	487	547	608	669	730	792	854	916	978	1041	1103	1167	1230	1295	1359	1424	1490	5
6	6	66	126	186	246	306	367	427	488	548	609	670	731	793	855	917	979	1042	1105	1168	1232	1296	1360	1425	1491	6
7	7	67	127	187	247	307	368	428	489	549	610	671	732	794	856	918	980	1043	1106	1169	1233	1297	1361	1426	1492	7
8	8	68	128	188	248	308	369	429	490	550	611	672	734	795	857	919	981	1044	1107	1170	1234	1298	1362	1427	1493	8
9	9	69	129	189	249	309	370	430	491	551	612	673	735	796	858	920	982	1045	1108	1171	1235	1299	1363	1428	1494	9
10	10	70	130	190	250	310	371	431	492	552	613	674	736	797	859	921	983	1046	1109	1172	1236	1300	1364	1430	1495	10
11	11	71	131	191	251	311	372	432	493	553	614	675	737	798	860	922	984	1047	1110	1173	1237	1301	1366	1431	1496	11
12	12	72	132	192	252	312	373	433	494	554	615	676	738	799	861	923	985	1048	1111	1174	1238	1302	1367	1432	1497	12
13	13	73	133	193	253	313	374	434	495	555	616	677	739	800	862	924	986	1049	1112	1175	1239	1303	1368	1433	1498	13
14	14	74	134	194	254	314	375	435	496	556	617	678	740	801	863	925	987	1050	1113	1176	1240	1304	1369	1434	1499	14
15	15	75	135	195	255	315	376	436	497	557	618	679	741	802	864	926	988	1051	1114	1177	1241	1305	1370	1435	1500	15
16	16	76	136	196	256	316	377	437	498	558	619	680	742	803	865	927	989	1052	1115	1178	1242	1306	1371	1436	1502	16
17	17	77	137	197	257	317	378	438	499	559	620	681	743	804	866	928	990	1053	1116	1179	1243	1307	1372	1437	1503	17
18	18	78	138	198	258	318	379	439	500	560	621	682	744	805	867	929	991	1054	1117	1181	1244	1308	1373	1438	1504	18
19	19	79	139	199	259	319	380	440	501	561	622	683	745	806	868	930	993	1055	1118	1182	1245	1310	1374	1439	1505	19
20	20	80	140	200	260	320	381	441	502	562	623	684	746	807	869	931	994	1056	1119	1183	1246	1311	1375	1440	1506	20
21	21	81	141	201	261	321	382	442	503	564	624	685	747	808	870	932	995	1057	1120	1184	1248	1312	1376	1441	1507	21
22	22	82	142	202	262	322	383	443	504	565	625	687	748	809	871	933	996	1058	1121	1185	1249	1313	1377	1443	1508	22
23	23	83	143	203	263	323	384	444	505	566	626	688	749	810	872	934	997	1059	1122	1186	1250	1314	1379	1444	1509	23
24	24	84	144	204	264	324	385	445	506	567	627	689	750	811	873	935	998	1060	1123	1187	1251	1315	1380	1445	1510	24
25	25	85	145	205	265	325	386	446	507	568	628	690	751	812	874	936	999	1061	1125	1188	1252	1316	1381	1446	1511	25
26	26	86	146	206	266	326	387	447	508	569	629	691	752	813	875	937	1000	1063	1126	1189	1253	1317	1382	1447	1513	26
27	27	87	147	207	267	327	388	448	509	570	631	692	753	815	876	938	1001	1064	1127	1190	1254	1318	1383	1448	1514	27
28	28	88	148	208	268	328	389	449	510	571	632	693	754	816	877	939	1002	1065	1128	1191	1255	1319	1384	1449	1515	28
29	29	89	149	209	269	330	390	450	511	572	633	694	755	817	878	941	1003	1066	1129	1192	1256	1320	1385	1450	1516	29

TABLE VI.—Meridional Parts.

′	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	′
30	30	90	150	210	270	331	391	451	512	573	634	695	756	818	879	942	1004	1067	1130	1193	1257	1321	1386	1451	1517	30
31	31	91	151	211	271	332	392	452	513	574	635	696	757	819	880	943	1005	1068	1131	1194	1258	1322	1387	1452	1518	31
32	32	92	152	212	272	333	393	453	514	575	636	697	758	820	882	944	1006	1069	1132	1195	1259	1324	1388	1453	1519	32
33	33	93	153	213	273	334	394	454	515	576	637	698	759	821	883	945	1007	1070	1133	1196	1260	1325	1389	1455	1520	33
34	34	94	154	214	274	335	395	455	516	577	638	699	760	822	884	946	1008	1071	1134	1198	1261	1326	1390	1456	1521	34
35	35	95	155	215	275	336	396	456	517	578	639	700	761	823	885	947	1009	1072	1135	1199	1262	1327	1392	1457	1522	35
36	36	96	156	216	276	337	397	457	518	579	640	701	762	824	886	948	1010	1073	1136	1200	1264	1328	1393	1458	1524	36
37	37	97	157	217	277	338	398	458	519	580	641	702	763	825	887	949	1011	1074	1137	1201	1265	1329	1394	1459	1525	37
38	38	98	158	218	278	339	399	459	520	581	642	703	764	826	888	950	1012	1075	1138	1202	1266	1330	1395	1460	1526	38
39	39	99	159	219	279	340	400	460	521	582	643	704	765	827	889	951	1013	1076	1139	1203	1267	1331	1396	1461	1527	39
40	40	100	160	220	280	341	401	461	522	583	644	705	766	828	890	952	1014	1077	1140	1204	1268	1332	1397	1462	1528	40
41	41	101	161	221	281	342	402	462	523	584	645	706	767	829	891	953	1015	1078	1141	1205	1269	1333	1398	1463	1529	41
42	42	102	162	222	282	343	403	463	524	585	646	707	768	830	892	954	1016	1079	1142	1206	1270	1334	1399	1464	1530	42
43	43	103	163	223	283	344	404	464	525	586	647	708	769	831	893	955	1018	1080	1144	1207	1271	1335	1400	1465	1531	43
44	44	104	164	224	284	345	405	465	526	587	648	709	770	832	894	956	1019	1081	1145	1208	1272	1336	1401	1467	1532	44
45	45	105	165	225	285	346	406	466	527	588	649	710	771	833	895	957	1020	1082	1146	1209	1273	1338	1402	1468	1533	45
46	46	106	166	226	286	347	407	467	528	589	650	711	772	834	896	958	1021	1084	1147	1210	1274	1339	1403	1469	1535	46
47	47	107	167	227	287	348	408	468	529	590	651	712	773	835	897	959	1022	1085	1148	1211	1275	1340	1405	1470	1536	47
48	48	108	168	228	288	349	409	469	530	591	652	713	774	836	898	960	1023	1086	1149	1212	1276	1341	1406	1471	1537	48
49	49	109	169	229	289	350	410	470	531	592	653	714	775	837	899	961	1024	1087	1150	1213	1277	1342	1407	1472	1538	49
50	50	110	170	230	290	351	411	471	532	593	654	715	777	838	900	962	1025	1088	1151	1215	1278	1343	1408	1473	1539	50
51	51	111	171	231	291	352	412	472	533	594	655	716	778	839	901	963	1026	1089	1152	1216	1280	1344	1409	1474	1540	51
52	52	112	172	232	292	353	413	473	534	595	656	717	779	840	902	964	1027	1090	1153	1217	1281	1345	1410	1475	1541	52
53	53	113	173	233	293	354	414	474	535	596	657	718	780	841	903	965	1028	1091	1154	1218	1282	1346	1411	1476	1542	53
54	54	114	174	234	294	355	415	476	536	597	658	719	781	842	904	966	1029	1092	1155	1219	1283	1347	1412	1477	1543	54
55	55	115	175	235	295	356	416	477	537	598	659	720	782	843	905	968	1030	1093	1156	1220	1284	1348	1413	1479	1544	55
56	56	116	176	236	296	357	417	478	538	599	660	721	783	844	906	969	1031	1094	1157	1221	1285	1349	1414	1480	1546	56
57	57	117	177	237	297	358	418	479	539	600	661	722	784	845	907	970	1032	1095	1158	1222	1286	1350	1415	1481	1547	57
58	58	118	178	238	298	359	419	480	540	601	662	723	785	846	908	971	1033	1096	1159	1223	1287	1352	1416	1482	1548	58
59	59	119	179	239	299	360	420	481	541	602	663	724	786	847	909	972	1034	1097	1160	1224	1288	1353	1418	1483	1549	59

TABLE VI.—Meridional Parts.

′	25°	26°	27°	28′	29′	30′	31°	32°	33′	34′	35′	36′	37′	38′	39°	40°	41°	42°	43°	44°	45°	′
0	1550	1616	1684	1751	1819	1888	1958	2028	2100	2171	2244	2318	2393	2468	2545	2623	2702	2782	2863	2946	3030	0
1	1551	1618	1685	1752	1821	1890	1959	2030	2101	2173	2246	2319	2394	2470	2546	2624	2703	2783	2864	2947	3031	1
2	1552	1619	1686	1753	1822	1891	1960	2031	2102	2174	2247	2320	2395	2471	2548	2625	2704	2784	2866	2949	3033	2
3	1553	1620	1687	1755	1823	1892	1962	2032	2103	2175	2248	2322	2396	2472	2549	2627	2706	2786	2867	2950	3034	3
4	1554	1621	1688	1756	1824	1893	1963	2033	2104	2176	2249	2323	2398	2473	2550	2628	2707	2787	2869	2951	3036	4
5	1556	1622	1689	1757	1825	1894	1964	2034	2105	2178	2250	2324	2399	2475	2551	2629	2708	2788	2870	2953	3037	5
6	1557	1623	1690	1758	1826	1895	1965	2035	2107	2179	2252	2325	2400	2476	2553	2631	2710	2790	2871	2954	3038	6
7	1558	1624	1691	1759	1827	1896	1966	2037	2108	2180	2253	2327	2401	2477	2554	2632	2711	2791	2873	2956	3040	7
8	1559	1625	1693	1760	1829	1898	1967	2038	2109	2181	2254	2328	2403	2478	2555	2633	2712	2792	2874	2957	3041	8
9	1560	1626	1694	1761	1830	1899	1969	2039	2110	2182	2255	2329	2404	2480	2557	2634	2714	2794	2875	2958	3043	9
10	1561	1628	1695	1762	1831	1900	1970	2040	2111	2184	2257	2330	2405	2481	2558	2636	2715	2795	2877	2960	3044	10
11	1562	1629	1696	1764	1832	1901	1971	2041	2113	2185	2258	2332	2406	2482	2559	2637	2716	2797	2878	2961	3046	11
12	1563	1630	1697	1765	1833	1902	1972	2043	2114	2186	2259	2333	2408	2484	2560	2638	2718	2798	2880	2963	3047	12
13	1564	1631	1698	1766	1834	1903	1973	2044	2115	2187	2260	2334	2409	2485	2562	2640	2719	2799	2881	2964	3048	13
14	1565	1632	1699	1767	1835	1905	1974	2045	2116	2188	2261	2335	2410	2486	2563	2641	2720	2801	2882	2965	3050	14
15	1567	1633	1700	1768	1837	1906	1976	2046	2117	2190	2263	2337	2411	2487	2564	2642	2722	2802	2884	2967	3051	15
16	1568	1634	1701	1769	1838	1907	1977	2047	2119	2191	2264	2338	2413	2489	2566	2644	2723	2803	2885	2968	3053	16
17	1569	1635	1703	1770	1839	1908	1978	2048	2120	2192	2265	2339	2414	2490	2567	2645	2724	2805	2886	2970	3054	17
18	1570	1637	1704	1772	1840	1909	1979	2050	2121	2193	2266	2340	2415	2491	2568	2646	2726	2806	2888	2971	3055	18
19	1571	1638	1705	1773	1841	1910	1980	2051	2122	2194	2268	2342	2416	2492	2569	2648	2727	2807	2889	2972	3057	19
20	1572	1639	1706	1774	1842	1912	1981	2052	2123	2196	2269	2343	2418	2494	2571	2649	2728	2809	2891	2974	3058	20
21	1573	1640	1707	1775	1843	1913	1983	2053	2125	2197	2270	2344	2419	2495	2572	2650	2729	2810	2892	2975	3060	21
22	1574	1641	1708	1776	1845	1914	1984	2054	2126	2198	2271	2345	2420	2496	2573	2651	2731	2811	2893	2976	3061	22
23	1575	1642	1709	1777	1846	1915	1985	2056	2127	2199	2272	2346	2422	2498	2575	2653	2732	2813	2895	2978	3063	23
24	1577	1643	1711	1778	1847	1916	1986	2057	2128	2200	2274	2348	2423	2499	2576	2654	2733	2814	2896	2979	3064	24
25	1578	1644	1712	1780	1848	1917	1987	2058	2129	2202	2275	2349	2424	2500	2577	2655	2735	2815	2897	2981	3065	25
26	1579	1645	1713	1781	1849	1918	1988	2059	2131	2203	2276	2350	2425	2501	2578	2657	2736	2817	2899	2982	3067	26
27	1580	1647	1714	1782	1850	1920	1990	2060	2132	2204	2277	2351	2427	2503	2580	2658	2737	2818	2900	2983	3068	27
28	1581	1648	1715	1783	1852	1921	1991	2061	2133	2205	2279	2353	2428	2504	2581	2659	2739	2820	2902	2985	3070	28
29	1582	1649	1716	1784	1853	1922	1992	2063	2134	2207	2280	2354	2429	2505	2582	2661	2740	2821	2903	2986	3071	29

TABLE VI.—Meridional Parts.

′	25°	26°	27°	28°	29°	30°	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°	41°	42°	43°	44°	45°	′
30	1583	1650	1717	1785	1854	1923	1993	2064	2135	2208	2281	2355	2430	2506	2584	2662	2742	2822	2904	2988	3073	30
31	1584	1651	1718	1786	1855	1924	1994	2065	2137	2209	2282	2356	2432	2508	2585	2663	2743	2824	2906	2989	3074	31
32	1585	1652	1720	1787	1856	1925	1995	2066	2138	2210	2283	2358	2433	2509	2586	2665	2744	2825	2907	2991	3075	32
33	1586	1653	1721	1789	1857	1927	1997	2067	2139	2211	2285	2359	2434	2510	2588	2666	2746	2826	2908	2992	3077	33
34	1588	1654	1722	1790	1858	1928	1998	2069	2140	2213	2286	2360	2435	2512	2589	2667	2747	2828	2910	2993	3078	34
35	1589	1656	1723	1791	1860	1929	1999	2070	2141	2214	2287	2361	2437	2513	2590	2669	2748	2829	2911	2995	3080	35
36	1590	1657	1724	1792	1861	1930	2000	2071	2143	2215	2288	2363	2438	2514	2591	2670	2750	2830	2913	2996	3081	36
37	1591	1658	1725	1793	1862	1931	2001	2072	2144	2216	2290	2364	2439	2515	2593	2671	2751	2832	2914	2998	3083	37
38	1592	1659	1726	1794	1863	1932	2002	2073	2145	2217	2291	2365	2440	2517	2594	2673	2752	2833	2915	2999	3084	38
39	1593	1660	1727	1795	1864	1934	2004	2075	2146	2219	2292	2366	2442	2518	2595	2674	2754	2834	2917	3000	3085	39
40	1594	1661	1729	1797	1865	1935	2005	2076	2147	2220	2293	2368	2443	2519	2597	2675	2755	2836	2918	3002	3087	40
41	1595	1662	1730	1798	1866	1936	2006	2077	2149	2221	2295	2369	2444	2521	2598	2676	2756	2837	2919	3003	3088	41
42	1596	1663	1731	1799	1868	1937	2007	2078	2150	2222	2296	2370	2445	2522	2599	2678	2758	2839	2921	3005	3090	42
43	1598	1664	1732	1800	1869	1938	2008	2079	2151	2224	2297	2371	2447	2523	2601	2679	2759	2840	2922	3006	3091	43
44	1599	1666	1733	1801	1870	1939	2010	2080	2152	2225	2298	2373	2448	2524	2602	2680	2760	2841	2924	3007	3093	44
45	1600	1667	1734	1802	1871	1941	2011	2082	2153	2226	2299	2374	2449	2526	2603	2682	2762	2843	2925	3009	3094	45
46	1601	1668	1735	1803	1872	1942	2012	2083	2155	2227	2301	2375	2451	2527	2604	2683	2763	2844	2926	3010	3095	46
47	1602	1669	1736	1805	1873	1943	2013	2084	2156	2228	2302	2376	2452	2528	2606	2684	2764	2845	2928	3012	3097	47
48	1603	1670	1738	1806	1875	1944	2014	2085	2157	2230	2303	2378	2453	2530	2607	2686	2766	2847	2929	3013	3098	48
49	1604	1671	1739	1807	1876	1945	2015	2086	2158	2231	2304	2379	2454	2531	2608	2687	2767	2848	2931	3014	3100	49
50	1605	1672	1740	1808	1877	1946	2017	2088	2159	2232	2306	2380	2456	2532	2610	2688	2768	2849	2932	3016	3101	50
51	1606	1673	1741	1809	1878	1948	2018	2089	2161	2233	2307	2381	2457	2533	2611	2690	2770	2851	2933	3017	3103	51
52	1608	1675	1742	1810	1879	1949	2019	2090	2162	2235	2308	2383	2458	2535	2612	2691	2771	2852	2935	3019	3104	52
53	1609	1676	1743	1811	1880	1950	2020	2091	2163	2236	2309	2384	2459	2536	2614	2692	2772	2854	2936	3020	3105	53
54	1610	1677	1744	1813	1881	1951	2021	2092	2164	2237	2311	2385	2461	2537	2615	2694	2774	2855	2937	3021	3107	54
55	1611	1678	1746	1814	1883	1952	2022	2094	2165	2238	2312	2386	2462	2538	2616	2695	2775	2856	2939	3023	3108	55
56	1612	1679	1747	1815	1884	1953	2024	2095	2167	2239	2313	2388	2463	2540	2617	2696	2776	2858	2940	3024	3110	56
57	1613	1680	1748	1816	1885	1955	2025	2096	2168	2241	2314	2389	2464	2541	2619	2698	2778	2859	2942	3026	3111	57
58	1614	1681	1749	1817	1886	1956	2026	2097	2169	2242	2316	2390	2466	2542	2620	2699	2779	2860	2943	3027	3113	58
59	1615	1682	1750	1818	1887	1957	2027	2098	2170	2243	2317	2391	2467	2544	2621	2700	2780	2862	2944	3029	3114	59

TABLE VI.—Meridional Parts.

′	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	57°	58°	59°	60°	61°	62°	63°	64°	65°	66°	′
0	3116	3203	3292	3382	3474	3569	3665	3764	3865	3968	4074	4183	4294	4409	4527	4649	4775	4905	5039	5179	5324	0
1	3117	3204	3293	3384	3476	3570	3667	3765	3866	3970	4076	4184	4296	4411	4529	4651	4777	4907	5042	5181	5326	1
2	3118	3206	3295	3385	3478	3572	3668	3767	3868	3971	4077	4186	4298	4413	4531	4653	4779	4909	5044	5184	5328	2
3	3120	3207	3296	3387	3479	3574	3670	3769	3870	3973	4079	4188	4300	4415	4533	4655	4781	4912	5046	5186	5331	3
4	3121	3209	3298	3388	3481	3575	3672	3770	3871	3975	4081	4190	4302	4417	4535	4657	4784	4914	5049	5188	5333	4
5	3123	3210	3299	3390	3482	3577	3673	3772	3873	3977	4083	4192	4304	4419	4537	4660	4786	4916	5051	5191	5336	5
6	3124	3212	3301	3391	3484	3578	3675	3774	3875	3978	4085	4194	4306	4421	4539	4662	4788	4918	5053	5193	5338	6
7	3126	3213	3302	3393	3485	3580	3677	3775	3877	3980	4086	4195	4308	4423	4541	4664	4790	4920	5055	5195	5341	7
8	3127	3214	3303	3394	3487	3582	3678	3777	3878	3982	4088	4197	4309	4425	4543	4666	4792	4923	5058	5198	5343	8
9	3129	3216	3305	3396	3488	3583	3680	3779	3880	3984	4090	4199	4311	4427	4545	4668	4794	4925	5060	5200	5346	9
10	3130	3217	3306	3397	3490	3585	3681	3780	3882	3985	4092	4201	4313	4429	4547	4670	4796	4927	5062	5203	5348	10
11	3131	3219	3308	3399	3492	3586	3683	3782	3883	3987	4094	4203	4315	4431	4549	4672	4798	4929	5065	5205	5351	11
12	3133	3220	3309	3400	3493	3588	3685	3784	3885	3989	4095	4205	4317	4433	4551	4674	4801	4931	5067	5207	5353	12
13	3134	3222	3311	3402	3495	3590	3686	3785	3887	3991	4097	4207	4319	4434	4553	4676	4803	4934	5069	5210	5356	13
14	3136	3223	3312	3403	3496	3591	3688	3787	3889	3992	4099	4208	4321	4436	4555	4678	4805	4936	5071	5212	5358	14
15	3137	3225	3314	3405	3498	3593	3690	3789	3890	3994	4101	4210	4323	4438	4557	4680	4807	4938	5074	5214	5361	15
16	3139	3226	3316	3407	3499	3594	3691	3790	3892	3996	4103	4212	4325	4440	4559	4682	4809	4940	5076	5217	5363	16
17	3140	3228	3317	3408	3501	3596	3693	3792	3894	3998	4104	4214	4327	4442	4562	4684	4811	4943	5078	5219	5366	17
18	3142	3229	3319	3410	3503	3598	3695	3794	3895	3999	4106	4216	4328	4444	4564	4687	4814	4945	5081	5222	5368	18
19	3143	3231	3320	3411	3504	3599	3698	3795	3897	4001	4108	4218	4330	4446	4566	4689	4816	4947	5083	5224	5371	19
20	3144	3232	3322	3413	3506	3601	3698	3797	3899	4003	4110	4220	4332	4448	4568	4691	4818	4949	5085	5226	5373	20
21	3146	3234	3323	3414	3507	3602	3699	3799	3901	4005	4112	4221	4334	4450	4570	4693	4820	4951	5088	5229	5376	21
22	3147	3235	3325	3416	3509	3604	3701	3800	3902	4006	4113	4223	4336	4452	4572	4695	4822	4954	5090	5231	5378	22
23	3149	3237	3326	3417	3510	3606	3703	3802	3904	4008	4115	4225	4338	4454	4574	4697	4824	4956	5092	5234	5380	23
24	3150	3238	3328	3419	3512	3607	3704	3804	3906	4010	4117	4227	4340	4456	4576	4699	4826	4958	5095	5236	5383	24
25	3152	3240	3329	3420	3514	3609	3706	3806	3907	4012	4119	4229	4342	4458	4578	4701	4829	4960	5097	5238	5385	25
26	3153	3241	3331	3422	3515	3610	3708	3807	3909	4014	4121	4231	4344	4460	4580	4703	4831	4963	5099	5241	5388	26
27	3155	3242	3332	3423	3517	3612	3709	3809	3911	4015	4122	4232	4346	4462	4582	4705	4833	4965	5102	5243	5390	27
28	3156	3244	3334	3425	3518	3614	3711	3811	3913	4017	4124	4234	4347	4464	4584	4707	4835	4967	5104	5246	5393	28
29	3157	3245	3335	3427	3520	3615	3713	3812	3914	4019	4126	4236	4349	4466	4586	4710	4837	4969	5106	5248	5395	29

TABLE VI.—Meridional Parts.

′	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	57°	58°	59°	60°	61°	62°	63°	64°	65°	66°	′
30	3159	3247	3337	3428	3521	3617	3714	3814	3916	4021	4128	4238	4351	4468	4588	4712	4839	4972	5108	5250	5398	30
31	3160	3248	3338	3430	3523	3618	3716	3816	3918	4022	4130	4240	4353	4470	4590	4714	4842	4974	5111	5253	5401	31
32	3162	3250	3340	3431	3525	3620	3717	3817	3919	4024	4132	4242	4355	4472	4592	4716	4844	4976	5113	5255	5403	32
33	3163	3251	3341	3433	3526	3622	3719	3819	3921	4026	4133	4244	4357	4474	4594	4718	4846	4978	5115	5258	5406	33
34	3165	3253	3343	3434	3528	3623	3721	3821	3923	4028	4135	4246	4359	4476	4596	4720	4848	4981	5118	5260	5408	34
35	3166	3254	3344	3436	3529	3625	3722	3822	3925	4029	4137	4247	4361	4478	4598	4722	4850	4983	5120	5263	5411	35
36	3168	3256	3346	3437	3531	3626	3724	3824	3926	4031	4139	4249	4363	4480	4600	4724	4852	4985	5122	5265	5413	36
37	3169	3257	3347	3439	3532	3628	3726	3826	3928	4033	4141	4251	4365	4482	4602	4726	4855	4987	5125	5267	5416	37
38	3171	3259	3349	3440	3534	3630	3727	3827	3930	4035	4142	4253	4367	4484	4604	4728	4857	4990	5127	5270	5418	38
39	3172	3260	3350	3442	3536	3631	3729	3829	3932	4037	4144	4255	4369	4486	4606	4731	4859	4992	5129	5272	5421	39
40	3173	3262	3352	3443	3537	3633	3731	3831	3933	4038	4146	4257	4370	4488	4608	4733	4861	4994	5132	5275	5423	40
41	3175	3263	3353	3445	3539	3634	3732	3832	3935	4040	4148	4259	4372	4490	4610	4735	4863	4996	5134	5277	5426	41
42	3176	3265	3355	3447	3540	3636	3734	3834	3937	4042	4150	4260	4374	4492	4612	4737	4865	4999	5136	5280	5428	42
43	3178	3266	3356	3448	3542	3638	3736	3836	3938	4044	4152	4262	4376	4494	4614	4739	4868	5001	5139	5282	5431	43
44	3179	3268	3358	3450	3543	3639	3737	3838	3940	4045	4153	4264	4378	4495	4616	4741	4870	5003	5141	5284	5433	44
45	3181	3269	3359	3451	3545	3641	3739	3839	3942	4047	4155	4266	4380	4497	4618	4743	4872	5005	5143	5287	5436	45
46	3182	3271	3361	3453	3547	3643	3741	3841	3944	4049	4157	4268	4382	4499	4620	4745	4874	5008	5146	5289	5438	46
47	3184	3272	3362	3454	3548	3644	3742	3843	3945	4051	4159	4270	4384	4501	4623	4747	4876	5010	5148	5292	5441	47
48	3185	3274	3364	3456	3550	3646	3744	3844	3947	4052	4161	4272	4386	4503	4625	4750	4879	5012	5151	5294	5443	48
49	3187	3275	3365	3457	3551	3647	3746	3846	3949	4054	4162	4274	4388	4505	4627	4752	4881	5014	5153	5297	5446	49
50	3188	3277	3367	3459	3553	3649	3747	3848	3951	4056	4164	4275	4390	4507	4629	4754	4883	5017	5155	5299	5448	50
51	3190	3278	3368	3460	3555	3651	3749	3849	3952	4058	4166	4277	4392	4509	4631	4756	4885	5019	5158	5301	5451	51
52	3191	3280	3370	3462	3556	3652	3750	3851	3954	4060	4168	4279	4394	4511	4633	4758	4887	5021	5160	5304	5454	52
53	3192	3281	3371	3464	3558	3654	3752	3853	3956	4061	4170	4281	4396	4513	4635	4760	4890	5023	5162	5306	5456	53
54	3194	3283	3373	3465	3559	3655	3754	3854	3958	4063	4172	4283	4398	4515	4637	4762	4892	5026	5165	5309	5459	54
55	3195	3284	3374	3467	3561	3657	3755	3856	3959	4065	4173	4285	4399	4517	4639	4764	4894	5028	5167	5311	5461	55
56	3197	3286	3376	3468	3562	3659	3757	3858	3961	4067	4175	4287	4401	4519	4641	4766	4896	5030	5169	5314	5464	56
57	3198	3287	3378	3470	3564	3660	3759	3860	3963	4069	4177	4289	4403	4521	4643	4769	4898	5033	5172	5316	5466	57
58	3200	3289	3379	3471	3566	3662	3760	3861	3964	4070	4179	4291	4405	4523	4645	4771	4901	5035	5174	5319	5469	58
59	3201	3290	3381	3473	3567	3664	3762	3863	3966	4072	4181	4292	4407	4525	4647	4773	4903	5037	5176	5321	5471	59

TABLE VI.—Meridional Parts.

′	67°	68°	69°	70°	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°	81°	82°	83°	84°	85°	′
0	5474	5631	5795	5966	6146	6335	6534	6746	6970	7210	7467	7745	8046	8375	8739	9145	9606	10137	10765	0
1	5477	5633	5797	5969	6149	6338	6538	6749	6974	7214	7472	7749	8051	8381	8745	9153	9614	10146	10776	1
2	5479	5636	5800	5972	6152	6341	6541	6753	6978	7218	7476	7754	8056	8387	8752	9160	9622	10156	10788	2
3	5482	5639	5803	5975	6155	6345	6545	6757	6982	7222	7481	7759	8061	8393	8758	9167	9631	10166	10799	3
4	5484	5642	5806	5978	6158	6348	6548	6760	6986	7227	7485	7764	8067	8398	8765	9174	9639	10175	10811	4
5	5487	5644	5809	5981	6161	6351	6552	6764	6990	7231	7490	7769	8072	8404	8771	9182	9647	10185	10822	5
6	5489	5647	5811	5984	6164	6354	6555	6768	6994	7235	7494	7774	8077	8410	8778	9189	9655	10195	10834	6
7	5492	5650	5814	5986	6167	6358	6558	6771	6997	7239	7498	7778	8083	8416	8784	9196	9664	10205	10846	7
8	5495	5652	5817	5989	6170	6361	6562	6775	7001	7243	7503	7783	8088	8422	8791	9203	9672	10214	10858	8
9	5497	5655	5820	5992	6173	6364	6565	6779	7005	7247	7507	7788	8093	8427	8797	9211	9680	10224	10869	9
10	5500	5658	5823	5995	6177	6367	6569	6782	7009	7252	7512	7793	8099	8433	8804	9218	9689	10234	10881	10
11	5502	5660	5825	5998	6180	6371	6572	6786	7013	7256	7516	7798	8104	8439	8810	9225	9697	10244	10893	11
12	5505	5663	5828	6001	6183	6374	6576	6790	7017	7260	7521	7803	8109	8445	8817	9233	9706	10254	10905	12
13	5507	5666	5831	6004	6186	6377	6579	6793	7021	7264	7525	7808	8115	8451	8823	9240	9714	10264	10917	13
14	5510	5668	5834	6007	6189	6380	6583	6797	7025	7268	7530	7813	8120	8457	8830	9248	9723	10273	10929	14
15	5513	5671	5837	6010	6192	6384	6586	6801	7029	7273	7535	7817	8125	8463	8836	9255	9731	10283	10941	15
16	5515	5674	5839	6013	6195	6387	6590	6804	7033	7277	7539	7822	8131	8469	8843	9262	9740	10293	10953	16
17	5518	5676	5842	6016	6198	6390	6593	6808	7037	7281	7544	7827	8136	8474	8849	9270	9748	10303	10965	17
18	5520	5679	5845	6019	6201	6394	6597	6812	7041	7285	7548	7832	8141	8480	8856	9277	9757	10314	10978	18
19	5523	5682	5848	6022	6205	6397	6600	6815	7045	7289	7553	7837	8147	8486	8863	9285	9765	10324	10990	19
20	5526	5685	5851	6025	6208	6400	6603	6819	7048	7294	7557	7842	8152	8492	8869	9292	9774	10334	11002	20
21	5528	5687	5854	6028	6211	6403	6607	6823	7052	7298	7562	7847	8158	8498	8876	9300	9783	10344	11014	21
22	5531	5690	5856	6031	6214	6407	6610	6826	7056	7302	7566	7852	8163	8504	8883	9307	9791	10354	11027	22
23	5533	5693	5859	6034	6217	6410	6614	6830	7060	7306	7571	7857	8168	8510	8889	9315	9800	10364	11039	23
24	5536	5695	5862	6037	6220	6413	6617	6834	7064	7311	7576	7862	8174	8516	8896	9322	9809	10374	11052	24
25	5539	5698	5865	6040	6223	6417	6621	6838	7068	7315	7580	7867	8179	8522	8903	9330	9817	10385	11064	25
26	5541	5701	5868	6043	6226	6420	6624	6841	7072	7319	7585	7872	8185	8528	8909	9337	9826	10395	11077	26
27	5544	5704	5871	6046	6230	6423	6628	6845	7076	7323	7589	7877	8190	8534	8916	9345	9835	10405	11089	27
28	5546	5706	5874	6049	6233	6427	6631	6849	7080	7328	7594	7882	8196	8540	8923	9353	9844	10416	11102	28
29	5549	5709	5876	6052	6236	6430	6635	6853	7084	7332	7599	7887	8201	8546	8930	9360	9852	10426	11115	29

TABLE VI.—Meridional Parts.

′	67°	68°	69°	70°	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°	81°	82°	83°	84°	85°	′
30	5552	5712	5879	6055	6239	6433	6639	6856	7088	7336	7603	7892	8207	8552	8936	9368	9861	10437	11127	30
31	5554	5715	5882	6058	6242	6437	6642	6860	7092	7341	7608	7897	8212	8558	8943	9376	9870	10447	11140	31
32	5557	5717	5885	6061	6245	6440	6646	6864	7096	7345	7612	7902	8218	8565	8950	9383	9879	10457	11153	32
33	5559	5720	5888	6064	6249	6443	6649	6868	7100	7349	7617	7907	8223	8571	8957	9391	9888	10468	11166	33
34	5562	5723	5891	6067	6252	6447	6653	6871	7104	7353	7622	7912	8229	8577	8963	9399	9897	10479	11179	34
35	5565	5725	5894	6070	6255	6450	6656	6875	7108	7358	7626	7917	8234	8583	8970	9407	9906	10489	11192	35
36	5567	5728	5896	6073	6258	6453	6660	6879	7112	7362	7631	7922	8240	8589	8977	9414	9915	10500	11205	36
37	5570	5731	5899	6076	6261	6457	6663	6883	7116	7366	7636	7927	8245	8595	8984	9422	9924	10510	11218	37
38	5573	5734	5902	6079	6264	6460	6667	6886	7120	7371	7640	7932	8251	8601	8991	9430	9933	10521	11231	38
39	5575	5736	5905	6082	6268	6463	6670	6890	7124	7375	7645	7937	8256	8607	8998	9438	9942	10532	11244	39
40	5578	5739	5908	6085	6271	6467	6674	6894	7128	7379	7650	7942	8262	8614	9005	9445	9951	10542	11257	40
41	5580	5742	5911	6088	6274	6470	6677	6898	7132	7384	7654	7948	8267	8620	9012	9453	9960	10553	11270	41
42	5583	5745	5914	6091	6277	6473	6681	6901	7136	7388	7659	7953	8273	8626	9018	9461	9969	10564	11284	42
43	5586	5747	5917	6094	6280	6477	6685	6905	7140	7392	7664	7958	8279	8632	9025	9469	9978	10575	11297	43
44	5588	5750	5919	6097	6283	6480	6688	6909	7145	7397	7668	7963	8284	8638	9032	9477	9987	10586	11310	44
45	5591	5753	5922	6100	6287	6483	6692	6913	7149	7401	7673	7968	8290	8644	9039	9485	9996	10597	11324	45
46	5594	5756	5925	6103	6290	6487	6695	6917	7153	7406	7678	7973	8295	8651	9046	9493	10005	10608	11337	46
47	5596	5758	5928	6106	6293	6490	6699	6920	7157	7410	7683	7978	8301	8657	9053	9501	10015	10619	11351	47
48	5599	5761	5931	6109	6296	6494	6702	6924	7161	7414	7687	7983	8307	8663	9060	9509	10024	10630	11365	48
49	5602	5764	5934	6112	6299	6497	6706	6928	7165	7419	7692	7989	8312	8669	9067	9517	10033	10641	11378	49
50	5604	5767	5937	6115	6303	6500	6710	6932	7169	7423	7697	7994	8318	8676	9074	9525	10043	10652	11392	50
51	5607	5770	5940	6118	6306	6504	6713	6936	7173	7427	7702	7999	8324	8682	9081	9533	10052	10663	11406	51
52	5610	5772	5943	6121	6309	6507	6717	6940	7177	7432	7706	8004	8329	8688	9088	9541	10061	10674	11420	52
53	5612	5775	5946	6124	6312	6511	6720	6943	7181	7436	7711	8009	8335	8695	9096	9549	10071	10685	11434	53
54	5615	5778	5948	6127	6315	6514	6724	6947	7185	7441	7716	8014	8341	8701	9103	9557	10080	10696	11448	54
55	5617	5781	5951	6130	6319	6517	6728	6951	7189	7445	7721	8020	8347	8707	9110	9565	10089	10708	11462	55
56	5620	5783	5954	6133	6322	6521	6731	6955	7194	7449	7725	8025	8352	8714	9117	9573	10099	10719	11476	56
57	5623	5786	5957	6136	6325	6524	6735	6959	7198	7454	7730	8030	8358	8720	9124	9581	10108	10730	11490	57
58	5625	5789	5960	6140	6328	6528	6738	6963	7202	7458	7735	8035	8364	8726	9131	9589	10118	10742	11504	58
59	5628	5792	5963	6143	6332	6531	6742	6966	7206	7463	7740	8040	8369	8733	9138	9598	10127	10753	11518	59

TABLE VII.—Length of a Degree of Longitude on each Parallel of Latitude.

Latitude.	Nautical miles.	Latitude.	Nautical miles.	Latitude.	Nautical miles.
°		°		°	
1	59·99	31	51·43	61	29·09
2	59·96	32	50·88	62	28·17
3	59·92	33	50·32	63	27·74
4	59·85	34	49·74	64	26·30
5	59·77	35	49·15	65	25·36
6	59·67	36	48·54	66	24·40
7	59·55	37	47·92	67	23·44
8	59·42	38	47·28	68	22·48
9	59·26	39	46·63	69	21·50
10	59·09	40	45·96	70	20·52
11	58·89	41	45·28	71	19·53
12	58·69	42	44·59	72	18·54
13	58·46	43	43·88	73	17·54
14	58·22	44	43·16	74	16·54
15	57·95	45	42·43	75	15·53
16	57·67	46	41·68	76	14·52
17	57·38	47	40·92	77	13·50
18	57·06	48	40·15	78	12·48
19	56·73	49	39·36	79	11·45
20	56·38	50	38·57	80	10·42
21	56·01	51	37·76	81	9·38
22	55·63	52	36·94	82	8·35
23	55·23	53	36·11	83	7·31
24	54·81	54	35·27	84	6·27
25	54·38	55	34·41	85	5·23
26	53·93	56	33·45	86	4·18
27	53·46	57	32·68	87	3·14
28	52·97	58	31·79	88	2·09
29	52·48	59	30·90	89	1·05
30	51·96	60	30·00	90	0·00

TABLE VIII.
Dip of Horizon, corrected for Refraction.

Height of eye.	Dip of Horizon.	Height of eye.	Dip of Horizon.
feet.	′ ″	feet.	′ ″
1	0 59	41	6 18
2	1 24	42	6 23
3	1 42	43	6 27
4	1 58	44	6 32
5	2 12	45	6 37
6	2 25	47	6 45
7	2 36	48	6 50
8	2 47	50	6 58
9	2 57	53	7 10
10	3 7	56	7 22
11	3 16	59	7 34
12	3 25	62	7 45
13	3 33	65	7 56
14	3 41	68	8 7
15	3 49	71	8 18
16	3 56	74	8 28
17	4 4	77	8 38
18	4 11	80	8 48
19	4 17	83	8 58
20	4 24	86	9 8
21	4 31	89	9 17
22	4 37	90	9 22
23	4 43	92	9 26
24	4 49	95	9 36
25	4 55	98	9 45
26	5 1	100	9 52
27	5 7	101	9 54
28	5 13	104	10 2
29	5 18	107	10 11
30	5 24	110	10 19
31	5 29	113	10 28
32	5 34	116	10 36
33	5 39	119	10 44
34	5 44	122	10 52
35	5 49	125	11 0
36	5 54	128	11 8
37	5 59	131	11 16
38	6 4	134	11 24
39	6 9	137	11 31
40	6 14	140	11 39

TABLE IX.
Dip of the Horizon at various distances from it.

Distance in miles.	Height of Eye. feet. 5	feet. 10	feet. 15	feet. 20	feet. 25	feet. 30
	′	′	′	′	′	′
0¼	11	22	34	45	56	68
0½	6	11	17	22	28	34
0¾	4	8	12	15	19	23
1	4	6	9	12	15	17
1¼	3	5	7	9	12	14
1½	3	4	6	8	10	12
2	2	3	5	6	8	10
2½	2	3	5	6	7	8
3	2	3	4	5	6	7
3½	2	3	4	5	6	6
4	2	3	4	4	5	6
5	2	3	4	4	5	5
6	2	3	4	4	5	5

TABLE X.—Reduction of Moon's Equatorial Parallax.

Lat.	Horizontal Parallax. ′ 54	′ 56	′ 58	′ 60	′ 62
	″	″	″	″	″
4	0·1	0·1	0·1	0·1	0·1
8	0·2	0·2	0·2	0·2	0·2
12	0·4	0·5	0·5	0·5	0·5
16	0·8	0·8	0·9	0·9	0·9
20	1·3	1·3	1·4	1·4	1·5
24	1·8	1·9	1·9	2·0	2·0
28	2·4	2·5	2·6	2·6	2·7
32	3·0	3·1	3·3	3·4	3·5
36	3·7	3·9	4·0	4·1	4·3
40	4·5	4·6	4·8	5·0	5·1
44	5·2	5·4	5·6	5·8	6·0
48	6·0	6·2	6·3	6·6	6·8
52	6·7	7·0	7·2	7·4	7·6
56	7·4	7·7	8·0	8·2	8·5
60	8·1	8·4	8·7	9·0	9·3
64	8·7	9·1	9·4	9·7	10·0
68	9·3	9·6	10·0	10·3	10·6
72	9·8	10·1	10·4	10·8	11·2
76	10·2	10·6	10·9	11·3	11·7
80	10·5	10·9	11·2	11·6	12·0

TABLE XI.

Augmentation of the Moon's Semidiameter.

Altitude.	Horizontal Semidiameter.					
	′ ″ 14 30	′ ″ 15 0	′ ″ 15 30	′ ″ 16 0	′ ″ 16 30	′ ″ 17 0
0	″	″	″	″	″	″
0	0	0	0	0	0	0
2	1	1	1	1	1	1
4	1	1	1	1	1	1
6	2	2	2	2	2	2
8	2	2	2	2	3	3
10	2	3	3	3	3	3
12	3	3	3	4	4	4
14	3	4	4	4	4	5
16	4	4	4	5	5	5
18	4	5	5	5	6	6
21	5	5	6	6	6	7
24	6	6	6	7	7	8
27	6	7	7	8	8	9
30	7	7	8	8	9	9
33	7	8	9	9	10	10
36	8	9	9	10	10	11
39	9	9	10	11	11	12
42	9	10	10	11	12	13
45	10	10	11	12	13	13
48	10	11	12	12	13	14
51	11	11	12	13	14	15
54	11	12	13	13	14	15
57	11	12	13	14	15	16
60	12	13	14	14	15	16
63	12	13	14	15	16	17
66	12	13	14	15	16	17
69	13	14	15	16	17	18
72	13	14	15	16	17	18
75	13	14	15	16	17	18
78	13	14	15	16	17	18
81	14	14	15	16	18	19
84	14	15	16	17	18	19
87	14	15	16	17	18	19
90	14	15	16	17	18	19

TABLE XII.

For converting Longitude into Time.

Long. ° ′	Time. H. M. M. S.	Long. ° ′	Time. H. M. M. S.	Long. ″	Time. Secs.
1	0 4	30	2 0	1	·067
2	0 8	40	2 40	2	·133
3	0 12	50	3 20	3	·200
4	0 16	60	4 0	4	·267
5	0 20	70	4 40	5	·333
6	0 24	80	5 20	6	·400
7	0 28	90	6 0	7	·467
8	0 32	100	6 40	8	·533
9	0 36	200	13 20	9	·600
10	0 40	300	20 0	10	·667
20	1 20				

TABLE XIII.

For converting Time into Longitude.

Time. H.	Long. °	Time. Min. Sec.	Long. ° ′ ′ ″	Time. Sec.	Long. ″
1	15	1	0 15	0·1	1·5
2	30	2	0 30	0·2	3·0
3	45	3	0 45	0·3	4·5
4	60	4	1 0	0·4	6·0
5	75	5	1 15	0·5	7·5
6	90	6	1 30	0·6	9·0
7	105	7	1 45	0·7	10·5
8	120	8	2 0	0·8	12·0
9	135	9	2 15	0·9	13·5
10	150	10	2 30		
11	165	20	5 0		
12	180	30	7 30		
16	240	40	10 0		
20	300	50	12 30		

TABLE XIV.

Parallax in Altitude of the Sun and Planets.

App. Alt.	Horizontal Parallax in Seconds.															
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31
0	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
3	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31
6	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31
9	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31
12	1	3	5	7	9	11	13	15	17	19	21	22	24	26	28	30
15	1	3	5	7	9	11	13	14	16	18	20	22	24	26	28	30
18	1	3	5	7	9	10	12	14	16	18	20	22	24	26	28	29
21	1	3	5	7	8	10	12	14	16	18	20	21	23	25	27	29
24	1	3	5	6	8	10	12	14	16	17	19	21	23	25	26	28
27	1	3	4	6	8	10	12	13	15	17	19	20	22	24	26	28
30	1	3	4	6	8	10	11	13	15	16	18	20	22	23	25	27
33	1	2	4	6	8	9	11	13	14	16	18	19	21	23	24	26
36	1	2	4	6	7	9	11	12	14	15	17	19	20	22	23	25
39	1	2	4	5	7	9	10	12	13	15	16	18	19	21	23	24
42	1	2	4	5	7	8	10	11	13	14	16	17	19	20	22	23
45	1	2	4	5	6	8	9	11	12	13	15	16	18	19	21	22
48	1	2	3	5	6	7	9	10	11	13	14	15	17	18	19	21
51	1	2	3	4	6	7	8	9	11	12	13	14	16	17	18	20
54	1	2	3	4	5	6	8	9	10	11	12	14	15	16	17	18
57	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17
60	1	2	3	4	5	5	7	8	9	10	11	12	13	14	15	16
63	0	1	2	3	4	5	6	7	8	9	10	10	11	12	13	14
66	0	1	2	3	4	4	5	6	7	8	9	9	10	11	12	13
69	0	1	2	3	3	4	5	5	6	7	8	8	9	10	10	11
72	0	1	2	2	3	3	4	5	5	6	6	7	8	8	9	10
75	0	1	1	2	2	3	3	4	4	5	5	6	6	7	8	8
78	0	1	1	1	2	2	3	3	4	4	4	5	5	6	6	6
81	0	0	1	1	1	2	2	2	3	3	3	4	4	4	5	5
84	0	0	1	1	1	1	1	2	2	2	2	2	3	3	3	3
87	0	0	0	0	0	1	1	1	1	1	1	1	1	1	2	2
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE XV.—Refraction of the Sun and Stars.

App. Alt.	Refraction.	App. Alt.	Refraction.	App. Alt.	Refraction.	App. Alt.	Refraction.	App. Alt.	Refraction.
° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″
1 0	24 21·2	10 0	5 19·8	19 0	2 47·7	28 0	1 49·2	37 0	1 17·2
10	23 9·6	10	5 15·1	10	2 46·3	10	1 48·4	10	1 16·7
20	22 3·4	20	5 10·4	20	2 44·8	20	1 47·6	20	1 16·2
30	21 1·9	30	5 5·7	30	2 43·3	30	1 46·9	30	1 15·8
40	20 4·8	40	5 1·0	40	2 41·8	40	1 46·2	40	1 15·3
50	19 11·5	50	4 56·3	50	2 40·3	50	1 45·5	50	1 14·8
2 0	18 22·2	11 0	4 51·7	20 0	2 38·8	29 0	1 44·8	38 0	1 14·4
10	17 36·3	10	4 47·7	10	2 37·4	10	1 44·1	10	1 14·0
20	16 53·2	20	4 43·7	20	2 36·0	20	1 43·4	20	1 13·5
30	16 13·4	30	4 39·7	30	2 34·6	30	1 42·7	30	1 13·1
40	15 36·0	40	4 35·7	40	2 33·2	40	1 42·0	40	1 12·7
50	15 0·9	50	4 31·8	50	2 31·9	50	1 41·3	50	1 12·2
3 0	14 28·1	12 0	4 27·9	21 0	2 30·6	30 0	1 40·6	39 0	1 11·8
10	13 57·3	10	4 24·5	10	2 29·3	10	1 39·9	10	1 11·3
20	13 28·5	20	4 21·1	20	2 28·1	20	1 39·3	20	1 10·9
30	13 1·3	30	4 17·7	30	2 26·9	30	1 38·6	30	1 10·5
40	12 35·6	40	4 14·3	40	2 25·6	40	1 38·0	40	1 10·1
50	12 11·3	50	4 10·5	50	2 24·4	50	1 37·3	50	1 9·7
4 0	11 48·3	13 0	4 7·5	22 0	2 23·2	31 0	1 36·7	40 0	1 9·3
10	11 26·6	10	4 4·5	10	2 22·1	10	1 36·1	10	1 8·9
20	11 6·1	20	4 1·5	20	2 20·9	20	1 35·5	20	1 8·5
30	10 46·7	30	3 58·6	30	2 19·8	30	1 34·9	30	1 8·1
40	10 28·3	40	3 55·7	40	2 18·7	40	1 34·3	40	1 7·7
50	10 10·9	50	3 52·7	50	2 17·6	50	1 33·7	50	1 7·3
5 0	9 54·3	14 0	3 49·8	23 0	2 16·5	32 0	1 33·1	41 0	1 6·9
10	9 38·4	10	3 47·2	10	2 15·4	10	1 32·5	10	1 6·5
20	9 23·4	20	3 44·6	20	2 14·4	20	1 31·9	20	1 6·1
30	9 4·0	30	3 42·0	30	2 13·3	30	1 31·3	30	1 5·7
40	8 55·3	40	3 39·4	40	2 12·3	40	1 30·7	40	1 5·3
50	8 42·3	50	3 36·8	50	2 11·2	50	1 30·2	50	1 4·9
6 0	8 29·9	15 0	3 34·3	24 0	2 10·2	33 0	1 29·6	42 0	1 4·6
10	8 18·2	10	3 32·1	10	2 9·2	10	1 29·0	10	1 4·2
20	8 6·6	20	3 29·8	20	2 8·2	20	1 28·4	20	1 3·8
30	7 55·6	30	3 27·5	30	2 7·2	30	1 27·8	30	1 3·5
40	7 44·9	40	3 25·2	40	2 6·2	40	1 27·3	40	1 3·1
50	7 34·7	50	3 22·9	50	2 5·2	50	1 26·7	50	1 2·8
7 0	7 24·7	16 0	3 20·7	25 0	2 4·3	34 0	1 26·2	43 0	1 2·4
10	7 15·3	10	3 18·5	10	2 3·4	10	1 25·6	10	1 2·0
20	7 6·3	20	3 16·5	20	2 2·5	20	1 25·1	20	1 1·7
30	6 57·7	30	3 14·5	30	2 1·6	30	1 24·6	30	1 1·3
40	6 49·6	40	3 12·5	40	2 0·7	40	1 24·1	40	1 1·0
50	6 41·9	50	3 10·5	50	1 59·8	50	1 23·6	50	1 0·6
8 0	6 34·4	17 0	3 8·5	26 0	1 58·9	35 0	1 23·1	44 0	1 0·3
10	6 27·1	10	3 6·6	10	1 58·0	10	1 22·6	10	1 0·0
20	6 20·0	20	3 4·8	20	1 57·2	20	1 22·1	20	0 59·6
30	6 13·1	30	3 3·0	30	1 56·4	30	1 21·6	30	0 59·2
40	6 6·4	40	3 1·2	40	1 55·6	40	1 21·1	40	0 58·9
50	5 59·9	50	2 59·4	50	1 54·7	50	1 20·6	50	0 58·5
9 0	5 53·5	18 0	2 57·6	27 0	1 53·9	36 0	1 20·1	45 0	0 58·2
10	5 47·4	10	2 55·9	10	1 53·2	10	1 19·6	10	0 57·8
20	5 41·5	20	2 54·3	20	1 52·4	20	1 19·1	20	0 57·5
30	5 35·9	30	2 52·6	30	1 51·6	30	1 18·6	30	0 57·2
40	5 30·4	40	2 51·0	40	1 50·8	40	1 18·1	40	0 56·9
50	5 25·1	50	2 49·3	50	1 50·0	50	1 17·6	50	0 56·5

TABLE XV.—Refraction of the Sun and Stars.

App. Alt.	Refraction.	App. Alt.	Refraction.	App. Alt.	Refraction.	App. Alt.	Refraction.	App. Alt.	Refraction.
° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″
46 0	0 56·2	55 0	0 40·8	64 0	0 28·4	73 0	0 17·8	82 0	0 8·2
10	0 55·8	10	0 40·5	10	0 28·2	10	0 17·6	10	0 8·1
20	0 55·5	20	0 40·3	20	0 28·0	20	0 17·4	20	0 7·9
30	0 55·2	30	0 40·0	30	0 27·8	30	0 17·2	30	0 7·8
40	0 54·9	40	0 39·8	40	0 27·6	40	0 17·0	40	0 7·6
50	0 54·6	50	0 39·5	50	0 27·4	50	0 16·8	50	0 7·4
47 0	0 54·3	56 0	0 39·3	65 0	0 27·2	74 0	0 16·7	83 0	0 7·2
10	0 54·0	10	0 39·0	10	0 26·9	10	0 16·5	10	0 7·0
20	0 53·6	20	0 38·8	20	0 26·7	20	0 16·3	20	0 6·9
30	0 53·3	30	0 38·5	30	0 26·5	30	0 16·1	30	0 6·7
40	0 53·0	40	0 38·3	40	0 26·3	40	0 16·0	40	0 6·5
50	0 52·7	50	0 38·0	50	0 26·1	50	0 15·8	50	0 6·3
48 0	0 52·4	57 0	0 37·8	66 0	0 25·9	75 0	0 15·6	84 0	0 6·1
10	0 52·1	10	0 37·6	10	0 25·7	10	0 15·4	10	0 5·9
20	0 51·8	20	0 37·3	20	0 25·5	20	0 15·2	20	0 5·8
30	0 51·5	30	0 37·1	30	0 25·3	30	0 15·0	30	0 5·6
40	0 51·2	40	0 36·9	40	0 25·1	40	0 14·8	40	0 5·5
50	0 50·9	50	0 36·6	50	0 24·9	50	0 14·7	50	0 5·3
49 0	0 50·6	58 0	0 36·4	67 0	0 24·7	76 0	0 14·5	85 0	0 5·1
10	0 50·4	10	0 36·2	10	0 24·5	10	0 14·3	10	0 4·9
20	0 50·1	20	0 36·0	20	0 24·3	20	0 14·2	20	0 4·8
30	0 49·8	30	0 35·7	30	0 24·1	30	0 14·0	30	0 4·6
40	0 49·5	40	0 35·5	40	0 23·9	40	0 13·8	40	0 4·5
50	0 49·2	50	0 35·2	50	0 23·7	50	0 13·7	50	0 4·3
50 0	0 48·9	59 0	0 35·0	68 0	0 23·5	77 0	0 13·5	86 0	0 4·1
10	0 48·6	10	0 34·8	10	0 23·4	10	0 13·4	10	0 3·9
20	0 48·3	20	0 34·6	20	0 23·2	20	0 13·2	20	0 3·7
30	0 48·1	30	0 34·3	30	0 23·0	30	0 13·0	30	0 3·6
40	0 47·8	40	0 34·1	40	0 22·8	40	0 12·8	40	0 3·4
50	0 47·5	50	0 33·8	50	0 22·6	50	0 12·6	50	0 3·3
51 0	0 47·2	60 0	0 33·6	69 0	0 22·4	78 0	0 12·4	87 0	0 3·1
10	0 46·9	10	0 33·4	10	0 22·2	10	0 12·2	10	0 2·9
20	0 46·6	20	0 33·1	20	0 22·0	20	0 12·0	20	0 2·8
30	0 46·3	30	0 32·9	30	0 21·8	30	0 11·9	30	0 2·6
40	0 46·1	40	0 32·7	40	0 21·6	40	0 11·7	40	0 2·4
50	0 45·8	50	0 32·5	50	0 21·4	50	0 11·5	50	0 2·2
52 0	0 45·6	61 0	0 32·3	70 0	0 21·2	79 0	0 11·3	88 0	0 2·0
10	0 45·2	10	0 32·0	10	0 21·0	10	0 11·2	10	0 1·9
20	0 45·0	20	0 31·8	20	0 20·8	20	0 11·0	20	0 1·7
30	0 44·6	30	0 31·6	30	0 20·6	30	0 10·8	30	0 1·5
40	0 44·4	40	0 31·4	40	0 20·4	40	0 10·7	40	0 1·3
50	0 44·1	50	0 31·2	50	0 20·2	50	0 10·5	50	0 1·1
53 0	0 43·9	62 0	0 31·0	71 0	0 20·0	80 0	0 10·3	89 0	0 1·0
10	0 43·6	10	0 30·8	10	0 19·8	10	0 10·1	10	0 0·9
20	0 43·3	20	0 30·6	20	0 19·6	20	0 10·0	20	0 0·7
30	0 43·1	30	0 30·4	30	0 19·4	30	0 9·8	30	0 0·5
40	0 42·8	40	0 30·2	40	0 19·2	40	0 9·6	40	0 0·3
50	0 42·6	50	0 30·0	50	0 19·0	50	0 9·4	50	0 0·1
54 0	0 42·3	63 0	0 29·7	72 0	0 18·9	81 0	0 9·2		
10	0 42·0	10	0 29·4	10	0 18·8	10	0 9·0		
20	0 41·8	20	0 29·2	20	0 18·6	20	0 8·9		
30	0 41·5	30	0 29·0	30	0 18·4	30	0 8·7		
40	0 41·3	40	0 28·8	40	0 18·2	4	0 8·6		
50	0 41·0	50	0 28·6	50	0 18·0	50	0 8·4		

TABLE XVI.—Correction for Table of Refraction.

Apparent altitude.	Height of the Thermometer.																
	20° +	24° +	28° +	32° +	36° +	40° +	44° +	48° +	52° −	56° −	60° −	64° −	68° −	72° −	76° −	80° −	
° ′	′ ″	′ ″	′ ″	′ ″	″	″	″	″	″	″	″	″	′ ″	′ ″	′ ″	′ ″	
1 0	1 59	1 43	1 25	1 9	53	38	23	8	7	21	36	50	1 3	1 17	1 30	1 43	
10	1 53	1 38	1 21	1 6	50	36	22	7	7	20	34	48	1 0	1 13	1 26	1 38	
20	1 48	1 33	1 17	1 3	48	34	21	7	6	19	32	45	0 57	1 9	1 21	1 33	
30	1 43	1 29	1 14	1 0	46	32	20	7	6	18	31	43	0 54	1 6	1 18	1 29	
40	1 39	1 25	1 11	0 57	44	31	18	6	6	18	30	41	0 52	1 4	1 15	1 25	
50	1 35	1 21	1 8	0 55	42	30	17	6	6	17	28	39	0 50	1 1	1 11	1 21	
2 0	1 31	1 18	1 5	0 53	39	29	17	6	5	16	27	37	0 48	0 58	1 8	1 18	
20	1 23	1 11	1 0	0 48	37	26	16	5	5	15	25	35	0 44	0 54	1 3	1 11	
40	1 17	1 6	0 55	0 44	34	24	14	5	5	14	23	32	0 41	0 50	0 58	1 6	
3 0	1 11	1 1	0 51	0 41	32	22	13	4	4	13	21	30	0 38	0 46	0 54	1 1	
20	1 6	0 57	0 47	0 38	29	21	13	4	4	12	20	28	0 35	0 43	0 50	0 57	
40	1 2	0 53	0 44	0 36	28	20	12	4	4	11	18	26	0 33	0 40	0 47	0 53	
4 0	0 58	0 49	0 41	0 33	26	18	11	4	4	10	17	24	0 31	0 37	0 44	0 50	
20	0 54	0 46	0 39	0 31	24	17	10	3	3	10	16	22	0 30	0 35	0 41	0 46	
40	0 51	0 43	0 37	0 29	23	16	10	3	3	9	15	21	0 28	0 33	0 38	0 43	
5 0	0 48	0 41	0 35	0 28	22	16	9	3	3	9	14	20	0 26	0 31	0 36	0 40	
30	0 45	0 38	0 32	0 26	20	14	9	3	3	8	13	19	0 24	0 29	0 34	0 38	
6 0	0 41	0 35	0 30	0 24	19	13	8	3	2	7	12	17	0 22	0 26	0 31	0 35	
30	0 38	0 33	0 28	0 22	17	12	7	2	2	7	11	15	0 20	0 24	0 29	0 33	
7 0	0 36	0 31	0 26	0 21	16	12	7	2	2	6	10	14	0 19	0 23	0 27	0 31	
30	0 34	0 29	0 24	0 20	15	11	6	2	2	6	9	13	0 17	0 21	0 25	0 29	
8 0	0 32	0 27	0 23	0 19	15	10	6	2	2	5	9	13	0 16	0 20	0 24	0 27	
9 0	0 28	0 24	0 20	0 16	13	9	5	2	2	5	8	11	0 14	0 18	0 21	0 24	
10 0	0 26	0 22	0 18	0 15	12	8	5	2	1	4	7	10	0 13	0 16	0 19	0 22	
11 0	0 23	0 20	0 17	0 14	11	8	5	2	1	4	7	9	0 12	0 15	0 18	0 20	
12 0	0 21	0 18	0 15	0 13	10	7	4	1	1	4	6	9	0 11	0 13	0 16	0 18	
13 0	0 20	0 17	0 14	0 12	9	7	4	1	1	3	6	8	0 10	0 12	0 15	0 17	
14 0	0 18	0 16	0 13	0 11	8	6	4	1	1	3	5	7	0 9	0 11	0 14	0 16	
15 0	0 17	0 15	0 12	0 10	8	6	3	1	1	3	5	7	0 9	0 11	0 13	0 15	
16 0	0 16	0 14	0 12	0 9	7	5	3	1	1	3	5	6	0 8	0 10	0 12	0 14	
17 0	0 15	0 13	0 11	0 9	7	5	3	1	1	3	4	6	0 8	0 9	0 11	0 13	
18 0	0 14	0 12	0 10	0 8	6	5	3	1	1	2	4	6	0 7	0 9	0 10	0 12	
19 0	0 13	0 11	0 9	0 8	6	4	3	1	1	2	4	5	0 7	0 8	0 10	0 11	
20 0	0 13	0 11	0 9	0 7	6	4	2	1	1	2	4	5	0 6	0 8	0 9	0 11	
22 0	0 11	0 10	0 8	0 7	5	4	2	1	1	2	3	5	0 6	0 7	0 8	0 10	
24 0	0 10	0 9	0 7	0 6	5	3	2	1	1	2	3	4	0 5	0 6	0 8	0 9	
26 0	0 9	0 8	0 7	0 6	4	3	2	1	1	2	3	4	0 5	0 6	0 7	0 8	
28 0	0 9	0 7	0 6	0 5	4	3	2	1	0	1	2	3	0 5	0 5	0 6	0 7	
30 0	0 8	0 7	0 6	0 5	4	3	2	1	0	1	2	3	0 4	0 5	0 6	0 7	
35 0	0 7	0 6	0 5	0 4	3	2	1	1	0	1	2	3	0 4	0 4	0 5	0 6	
40 0	0 6	0 5	0 4	0 3	3	2	1	0	0	1	2	2	0 3	0 3	0 4	0 5	
45 0	0 5	0 4	0 3	0 3	2	2	1	0	0	1	1	2	0 2	0 3	0 3	0 4	
50 0	0 4	0 3	0 3	0 2	2	1	1	0	0	1	1	2	0 2	0 2	0 3	0 3	
55 0	0 3	0 3	0 2	0 2	2	1	1	0	0	1	1	1	0 2	0 2	0 2	0 3	
60 0	0 3	0 2	0 2	0 2	1	1	1	0	0	0	1	1	0 1	0 2	0 2	0 2	
65 0	0 2	0 2	0 2	0 1	1	1	0	0	0	0	1	1	0 1	0 1	0 2	0 2	
70 0	0 2	0 1	0 1	0 1	1	1	0	0	0	0	1	1	0 1	0 1	0 1	0 1	
80 0	0 1	0 1	0 1	0 0	0	0	0	0	0	0	1	0	0 0	0 1	0 1	0 1	

Height of the Barometer.	− 28·26	− 28·56	− 28·85	− 29·15	− 29·45	+ 29·75	+ 30·05	+ 30·35	+ 30·64	+ 30·93
	+	+	+	+	+	−	−	−	−	−

TABLE XVII.—Correction of the Moon's Altitude.

P. P. for Alt.	Moon's App. Alt.	Moon's Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	P. P. for Par.
′ ″	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	
	2 0	35 36	36 36	37 36	38 36	39 36	40 36	41 36	42 36	
+	10	36 22	37 22	38 22	39 22	40 22	41 22	42 22	43 22	′ ″
1 4	20	37 4	38 4	39 4	40 4	41 4	42 4	43 4	44 4	1 1·0
2 7	30	37 44	38 44	39 44	40 44	41 44	42 44	43 44	44 44	2 2·0
3 11	40	38 20	39 20	40 20	41 20	42 20	43 20	44 20	45 20	3 3·0
4 15	50	38 55	39 55	40 55	41 55	42 55	43 55	44 55	45 55	4 4·0
5 18	3 0	39 28	40 27	41 27	42 27	43 27	44 27	45 27	46 27	5 5·0
6 22	10	39 58	40 58	41 58	42 58	43 58	44 58	45 58	46 58	6 6·0
7 26	20	40 26	41 26	42 26	43 25	44 25	45 25	46 25	47 25	7 7·0
8 29	30	40 53	41 53	42 53	43 52	44 52	45 52	46 52	47 52	8 8·0
9 33	40	41 17	42 17	43 17	44 17	45 17	46 17	47 17	48 17	9 9·0
	50	41 42	42 42	43 41	44 41	45 41	46 41	47 41	48 41	
	4 0	42 4	43 4	44 4	45 4	46 4	47 4	48 3	49 3	
′ ″	10	42 25	43 24	44 24	45 24	46 24	47 24	48 23	49 23	′ ″
1 2	20	42 45	43 44	44 44	45 44	46 44	47 44	48 44	49 44	1 1·0
2 4	30	43 3	44 3	45 3	46 2	47 2	48 2	49 2	50 2	2 2·0
3 5	40	43 21	44 21	45 21	46 21	47 21	48 20	49 20	50 20	3 3·0
4 7	50	43 38	44 37	45 37	46 37	47 36	48 36	49 36	50 36	4 4·0
5 9	5 0	43 53	44 53	45 53	46 53	47 53	48 53	49 52	50 52	5 5·0
6 11	10	44 9	45 9	46 8	47 8	48 8	49 8	50 8	51 7	6 6·0
7 12	20	44 23	45 23	46 23	47 22	48 22	49 21	50 21	51 21	7 7·0
8 14	30	44 36	45 36	46 35	47 35	48 35	49 35	50 34	51 34	8 8·0
9 16	40	44 49	45 49	46 49	47 48	48 48	49 48	50 48	51 47	9 9·0
	50	45 1	46 1	47 1	48 0	49 0	49 59	50 59	51 59	
	6 0	45 12	46 12	47 11	48 11	49 11	50 11	51 10	52 10	
′ ″	10	45 23	46 23	47 23	48 22	49 22	50 22	51 21	52 21	′ ″
1 1	20	45 33	46 33	47 33	48 32	49 32	50 31	51 31	52 31	1 1·0
2 2	30	45 43	46 43	47 42	48 42	49 42	50 41	51 41	52 41	2 2·0
3 3	40	45 53	46 53	47 52	48 52	49 52	50 51	51 50	52 50	3 3·0
4 4	50	46 2	47 2	48 1	49 1	50 0	51 0	51 59	52 59	4 4·0
5 5	7 0	46 11	47 10	48 10	49 10	50 9	51 9	52 8	53 8	5 5·0
6 6	10	46 20	47 19	48 19	49 18	50 18	51 17	52 17	53 16	6 6·0
7 7	20	46 28	47 27	48 26	49 26	50 26	51 25	52 25	53 24	7 7·0
8 8	30	46 34	47 34	48 33	49 33	50 32	51 32	52 31	53 31	8 8·0
9 9	40	46 41	47 41	48 40	49 39	50 39	51 38	52 38	53 37	9 9·0
	50	46 48	47 47	48 47	49 46	50 46	51 45	52 44	53 44	
	8 0	46 54	47 54	48 53	49 53	50 52	51 52	52 51	53 51	
′ ″	10	47 0	47 59	48 59	49 58	50 58	51 57	52 56	53 56	′ ″
1 1	20	47 6	48 5	49 5	50 4	51 3	52 3	53 2	54 2	1 1·0
2 1	30	47 12	48 11	49 10	50 9	51 9	52 8	53 7	54 7	2 2·0
3 2	40	47 17	48 16	49 16	50 15	51 14	52 14	53 13	54 12	3 3·0
4 2	50	47 22	48 21	49 20	50 19	51 19	52 18	53 17	54 17	4 4·0
5 3	9 0	47 26	48 25	49 25	50 24	51 23	52 22	53 22	54 21	5 5·0
6 3	10	47 32	48 31	49 30	50 29	51 29	52 28	53 27	54 26	6 6·0
7 4	20	47 35	48 34	49 34	50 33	51 32	52 31	53 31	54 30	7 7·0
8 4	30	47 40	48 39	49 38	50 37	51 36	52 35	53 35	54 34	8 8·0
9 5	40	47 44	48 43	49 42	50 41	51 41	52 40	53 39	54 38	9 9·0
	50	47 48	48 46	49 46	50 45	51 44	52 43	53 42	54 41	

TABLE XVII.—Correction of the Moon's Altitude.

P. P. for Alt.	Moon's App. Alt.	Moon's Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	P. P. for Par.
	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	
′ ″	10 0	47 51	48 50	49 49	50 48	51 47	52 46	53 45	54 44	
+	10	47 54	48 53	49 52	50 52	51 50	52 49	53 49	54 47	′ ″
1 0	20	47 57	48 57	49 55	50 55	51 54	52 52	53 52	54 51	1 1·0
2 0	30	48 1	49 0	49 59	50 58	51 57	52 56	53 55	54 54	2 2·0
3 1	40	48 4	49 3	50 2	51 1	52 0	52 59	53 58	54 57	3 2·9
4 1	50	48 6	49 5	50 4	51 3	52 2	53 1	54 0	54 59	4 3·9
5 1	11 0	48 9	49 7	50 6	51 5	52 4	53 3	54 2	55 1	5 4·9
6 1	10	48 11	49 10	50 8	51 7	52 6	53 5	54 4	55 3	6 5·9
7 1	20	48 13	49 12	50 11	51 9	52 8	53 7	54 6	55 5	7 6·9
8 2	30	48 15	49 14	50 13	51 12	52 10	53 9	54 8	55 7	8 7·9
9 2	40	48 17	49 16	50 14	51 13	52 12	53 11	54 10	55 8	9 8·8
	50	48 19	49 18	50 17	51 15	52 14	53 13	54 11	55 10	
	12 0	48 21	49 20	50 19	51 17	52 16	53 15	54 13	55 12	
′ ″	10	48 23	49 22	50 20	51 19	52 18	53 16	54 15	55 14	′ ″
1 0	20	48 24	49 23	50 22	51 20	52 19	53 17	54 16	55 15	1 1·0
2 0	30	48 26	49 25	50 23	51 22	52 21	53 19	54 17	55 16	2 2·0
3 0	40	48 27	49 26	50 24	51 23	52 21	53 20	54 18	55 17	3 2·9
4 0	50	48 28	49 27	50 25	51 24	52 22	53 21	54 19	55 18	4 3·9
5 1	13 0	48 29	49 27	50 26	51 24	52 23	53 21	54 20	55 19	5 4·9
6 1	10	48 31	49 29	50 28	51 26	52 25	53 23	54 21	55 19	6 5·9
7 1	20	48 31	49 30	50 28	51 27	52 25	53 24	54 22	55 20	7 6·9
8 1	30	48 33	49 30	50 29	51 27	52 26	53 24	54 22	55 20	8 7·9
9 1	40	48 32	49 31	50 29	51 28	52 26	53 24	54 22	55 21	9 8·8
	50	48 33	49 31	50 30	51 28	52 26	53 24	54 23	55 21	
	14 0	48 34	49 32	50 30	51 29	52 27	53 25	54 23	55 21	
′ ″	10	48 34	49 33	50 31	51 29	52 27	53 26	54 24	55 22	′ ″
1 0	20	48 34	49 32	50 31	51 29	52 27	53 25	54 24	55 22	1 1·0
2 0	30	48 35	49 33	50 31	51 29	52 27	53 25	54 24	55 22	2 1·9
3 0	40	48 35	49 34	50 32	51 29	52 28	53 26	54 23	55 22	3 2·9
4 0	50	48 35	49 33	50 31	51 29	52 27	53 25	54 23	55 21	4 3·9
5 0	15 0	48 36	49 34	50 31	51 30	52 27	53 25	54 23	55 21	5 4·8
6 0	10	48 35	49 33	50 31	51 29	52 27	53 25	54 23	55 21	6 5·8
7 0	20	48 35	49 33	50 31	51 29	52 26	53 24	54 22	55 20	7 6·8
8 0	30	48 35	49 33	50 31	51 28	52 26	53 24	54 22	55 20	8 7·7
9 0	40	48 34	49 33	50 30	51 28	52 26	53 24	54 21	55 19	9 8·7
	50	48 34	49 32	50 30	51 27	52 25	53 23	54 20	55 18	
	16 0	48 34	49 31	50 29	51 26	52 24	53 22	54 20	55 17	
′ ″	10	48 33	49 31	50 28	51 26	52 24	53 21	54 19	55 16	′ ″
—										
1 0	20	48 32	49 30	50 27	51 25	52 23	53 20	54 18	55 15	1 1·0
2 0	30	48 32	49 29	50 26	51 24	52 22	53 19	54 17	55 14	2 1·9
3 0	40	48 31	49 28	50 26	51 24	52 21	53 18	54 16	55 13	3 2·9
4 0	50	48 30	49 27	50 25	51 23	52 20	53 17	54 15	55 12	4 3·9
5 1	17 0	48 29	49 27	50 24	51 22	52 19	53 16	54 14	55 11	5 4·8
6 1	10	48 28	49 26	50 24	51 21	52 18	53 15	54 13	55 10	6 5·8
7 1	20	48 28	49 25	50 23	51 20	52 17	53 14	54 12	55 9	7 6·8
8 1	30	48 27	49 24	50 22	51 19	52 16	53 13	54 10	55 8	8 7·7
9 1	40	48 26	49 24	50 21	51 18	52 15	53 12	54 9	55 6	9 8·6
	50	48 26	49 23	50 20	51 17	52 14	53 11	54 8	55 5	

TABLE XVII.—Correction of the Moon's Altitude.

P. P. for Alt.	Moon's App. Alt.	Moon's Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	P. P. for Par.
′ ″	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	
	18 0	48 24	49 21	50 18	51 15	52 12	53 9	54 6	55 3	
—	10	48 23	49 20	50 17	51 14	52 11	53 8	54 5	55 2	″
1 0	20	48 22	49 19	50 16	51 13	52 10	53 7	54 3	55 0	1 0·9
2 0	30	48 20	49 17	50 14	51 10	52 7	53 4	54 1	54 58	2 1·9
3 0	40	48 19	49 16	50 12	51 9	52 6	53 3	53 59	54 56	3 2·8
4 1	50	48 18	49 15	50 11	51 8	52 4	53 1	53 58	54 55	4 3·8
5 1	19 0	48 16	49 12	50 9	51 5	52 2	52 59	53 56	54 53	5 4·7
6 1	10	48 15	49 11	50 8	51 4	52 1	52 58	53 54	54 51	6 5·7
7 1	20	48 12	49 9	50 5	51 2	51 59	52 55	53 52	54 49	7 6·7
8 1	30	48 11	49 8	50 4	51 1	51 57	52 54	53 51	54 47	8 7·6
9 1	40	48 9	49 5	50 2	50 58	51 55	52 52	53 48	54 44	9 8·5
	50	48 8	49 4	50 1	50 57	51 54	52 50	53 46	54 43	
	20 0	48 5	49 2	49 58	50 55	51 51	52 47	53 44	54 40	
′ ″	10	48 3	49 0	49 56	50 53	51 48	52 45	53 42	54 38	′ ″
1 0	20	48 2	48 58	49 55	50 51	51 47	52 43	53 40	54 36	1 0·9
2 0	30	48 0	48 56	49 52	50 48	51 45	52 41	53 37	54 33	2 1·9
3 1	40	47 58	48 54	49 50	50 46	51 42	52 38	53 34	54 30	3 2·8
4 1	50	47 56	48 52	49 48	50 44	51 41	52 36	53 32	54 28	4 3·7
5 1	21 0	47 54	48 50	49 46	50 42	51 38	52 34	53 30	54 26	5 4·7
6 1	10	47 53	48 48	49 44	50 40	51 35	52 32	53 27	54 23	6 5·6
7 2	20	47 50	48 46	49 42	50 37	51 34	52 30	53 25	54 21	7 6·6
8 2	30	47 47	48 43	49 39	50 35	51 31	52 27	53 22	54 19	8 7·5
9 2	40	47 45	48 41	49 36	50 32	51 28	52 24	53 20	54 15	9 8·4
	50	47 44	48 39	49 35	50 31	51 26	52 22	53 18	54 13	
	22 0	47 41	48 37	49 32	50 28	51 24	52 19	53 15	54 11	
′ ″	10	47 39	48 34	49 30	50 25	51 21	52 16	53 12	54 7	′ ″
1 0	20	47 36	48 31	49 27	50 22	51 18	52 13	53 9	54 4	1 0·9
2 1	30	47 33	48 29	49 24	50 20	51 15	52 11	53 6	54 2	2 1·8
3 1	40	47 31	48 26	49 21	50 16	51 12	52 6	53 2	53 57	3 2·8
4 1	50	47 28	48 23	49 19	50 14	51 9	52 5	53 0	53 55	4 3·8
5 1	23 0	47 26	48 21	49 16	50 11	51 6	52 2	52 57	53 52	5 4·7
6 2	10	47 24	48 19	49 14	50 9	51 4	51 59	52 54	53 50	6 5·6
7 2	20	47 21	48 16	49 11	50 6	51 2	51 56	52 51	53 47	7 6·5
8 2	30	47 18	48 13	49 9	50 3	50 58	51 54	52 48	53 43	8 7·4
9 2	40	47 16	48 10	49 5	50 1	50 55	51 50	52 45	53 40	9 8·3
	50	47 13	48 8	49 2	49 57	50 52	51 47	52 42	53 37	
	24 0	47 10	48 5	49 0	49 54	50 49	51 44	52 39	53 34	
′ ″	10	47 7	48 2	48 56	49 51	50 46	51 41	52 35	53 30	′ ″
1 0	20	47 4	47 59	48 54	49 48	50 43	51 38	52 32	53 27	1 0·9
2 1	30	47 1	47 56	48 51	49 46	50 41	51 35	52 29	53 23	2 1·8
3 1	40	46 58	47 53	48 47	49 42	50 37	51 31	52 25	53 20	3 2·7
4 1	50	46 56	47 50	48 44	49 39	50 33	51 27	52 22	53 17	4 3·6
5 2	25 0	46 52	47 47	48 41	49 36	50 30	51 24	52 19	53 13	5 4·5
6 2	10	46 49	47 44	48 38	49 32	50 26	51 21	52 15	53 10	6 5·4
7 2	20	46 46	47 40	48 34	49 28	50 22	51 17	52 11	53 5	7 6·4
8 3	30	46 42	47 36	48 30	49 25	50 19	51 13	52 7	53 2	8 7·2
9 3	40	46 39	47 33	48 27	49 22	50 16	51 10	52 4	52 58	9 8·2
	50	46 36	47 30	48 24	49 18	50 12	51 6	52 0	52 54	

TABLE XVII.—Correction of the Moon's Altitude.

P. P. for Alt.	Moon's App. Alt.	Moon's Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	P. P. for Par.
	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	
′ ″	26 0	46 33	47 27	48 21	49 15	50 9	51 3	51 57	52 51	
—	10	46 30	47 24	48 18	49 12	50 6	50 59	51 53	52 47	′ ″
1 0	20	46 27	47 20	48 14	49 8	50 2	50 56	51 49	52 43	1 0·9
2 1	30	46 24	47 17	48 11	49 5	49 59	50 52	51 46	52 39	2 1·8
3 1	40	46 20	47 13	48 6	49 1	49 54	50 47	51 41	52 35	3 2·7
4 1	50	46 16	47 10	48 3	48 57	49 50	50 44	51 37	52 31	4 3·5
5 2	27 0	46 13	47 7	48 0	48 53	49 47	50 40	51 34	52 27	5 4·4
6 2	10	46 9	47 3	47 56	48 50	49 43	50 36	51 30	52 23	6 5·3
7 2	20	46 6	47 0	47 53	48 46	49 39	50 33	51 26	52 19	7 6·3
8 3	30	46 2	46 56	47 48	48 42	49 35	50 28	51 21	52 15	8 7·1
9 3	40	45 59	46 52	47 45	48 38	49 31	50 24	51 17	52 11	9 8·0
	50	45 55	46 48	47 41	48 34	49 27	50 20	51 14	52 6	
	28 0	45 52	46 45	47 38	48 31	49 24	50 16	51 10	52 3	
′ ″	10	45 49	46 42	47 35	48 28	49 21	50 14	51 7	51 59	′ ″
1 0	20	45 45	46 38	47 30	48 23	49 16	50 9	51 2	51 54	1 0·9
2 1	30	45 41	46 34	47 27	48 19	49 12	50 5	50 58	51 51	2 1·8
3 1	40	45 37	46 31	47 23	48 16	49 8	50 1	50 54	51 46	3 2·6
4 2	50	45 33	46 26	47 19	48 11	49 4	49 56	50 49	51 41	4 3·5
5 2	29 0	45 29	46 21	47 14	48 6	48 59	49 51	50 44	51 36	5 4·4
6 2	10	45 25	46 18	47 10	48 2	48 55	49 47	50 39	51 32	6 5·3
7 3	20	45 22	46 14	47 6	47 58	48 51	49 43	50 36	51 28	7 6·2
8 3	30	45 17	46 9	47 1	47 54	48 46	49 38	50 30	51 23	8 7·0
9 4	40	45 13	46 5	46 58	47 50	48 42	49 34	50 26	51 18	9 7·9
	50	45 9	46 2	46 54	47 46	48 38	49 31	50 22	51 14	
	30 0	45 5	45 57	46 49	47 41	48 33	49 25	50 17	51 9	
′ ″	10	45 1	45 53	46 45	47 37	48 28	49 21	50 12	51 4	′ ″
1 0	20	44 58	45 49	46 41	47 33	48 25	49 16	50 8	51 0	1 0·9
2 1	30	44 53	45 44	46 36	47 28	48 19	49 11	50 3	50 55	2 1·7
3 1	40	44 49	45 41	46 32	47 24	48 15	49 7	49 59	50 50	3 2·6
4 2	50	44 44	45 36	46 27	47 18	48 10	49 2	49 53	50 45	4 3·4
5 2	31 0	44 40	45 31	46 23	47 15	48 6	48 57	49 49	50 40	5 4·3
6 3	10	44 36	45 27	46 18	47 9	48 1	48 52	49 43	50 35	6 5·2
7 3	20	44 31	45 23	46 14	47 5	47 56	48 48	49 39	50 30	7 6·1
8 4	30	44 27	45 19	46 10	47 1	47 52	48 44	49 35	50 26	8 6·8
9 4	40	44 24	45 15	46 6	46 57	47 48	48 39	49 30	50 21	9 7·7
	50	44 19	45 10	46 1	46 52	47 43	48 34	49 25	50 16	
	32 0	44 14	45 5	45 56	46 47	47 38	48 29	49 20	50 11	
′ ″	10	44 10	45 1	45 51	46 42	47 33	48 23	49 14	50 5	′ ″
1 0	20	44 6	44 56	45 47	46 38	47 29	48 19	49 10	50 0	1 0·8
2 1	30	44 0	44 51	45 42	46 33	47 23	48 14	49 4	49 55	2 1·7
3 1	40	43 57	44 47	45 37	46 28	47 19	48 9	49 0	49 50	3 2·5
4 2	50	43 51	44 42	45 32	46 22	47 13	48 3	48 54	49 45	4 3·3
5 2	33 0	43 47	44 38	45 28	46 18	47 8	47 59	48 49	49 40	5 4·2
6 3	10	43 43	44 33	45 24	46 14	47 4	47 54	48 44	49 35	6 5·0
7 3	20	43 39	44 29	45 19	46 9	47 0	47 49	48 40	49 30	7 5·9
8 4	30	43 34	44 24	45 14	46 4	46 54	47 44	48 34	49 24	8 6·7
9 4	40	43 29	44 20	45 10	45 59	46 49	47 39	48 29	49 19	9 7·5
	50	43 25	44 14	45 4	45 54	46 44	47 34	48 23	49 13	

TABLE XVII.—Correction of the Moon's Altitude.

P. P. for Alt.	Moon's App. Alt.	Moon's Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	P. P. for Par.
	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	
′ ″	34 0	43 20	44 10	45 0	45 50	46 39	47 29	48 18	49 8	
—	10	43 15	44 5	44 54	45 44	46 33	47 23	48 12	49 2	′ ″
1 1	20	43 10	44 0	44 49	45 39	46 28	47 18	48 8	48 57	1 0·8
2 1	30	43 5	43 55	44 44	45 34	46 23	47 12	48 2	48 51	2 1·6
3 2	40	43 1	43 50	44 40	45 29	46 18	47 8	47 57	48 46	3 2·4
4 2	50	42 55	43 45	44 34	45 23	46 13	47 2	47 51	48 40	4 3·3
5 3	35 0	42 51	43 40	44 29	45 18	46 8	46 57	47 46	48 35	5 4·1
6 3	10	42 45	43 35	44 24	45 13	46 2	46 51	47 40	48 29	6 5·0
7 4	20	42 41	43 30	44 19	45 8	45 57	46 46	47 35	48 24	7 5·8
8 4	30	42 36	43 25	44 13	45 2	45 51	46 40	47 29	48 18	8 6·5
9 5	40	42 31	43 20	44 9	45 58	45 46	46 35	47 24	48 13	9 7·4
	50	42 26	43 14	44 3	45 52	45 40	46 29	47 17	48 6	
	36 0	42 21	43 9	43 58	44 47	45 35	46 24	47 12	48 1	
′ ″	10	42 15	43 4	43 53	44 41	45 29	46 18	47 6	47 55	′ ″
1 1	20	42 11	42 59	43 48	44 36	45 24	46 13	47 1	47 49	1 0·8
2 1	30	42 6	42 54	43 42	44 30	45 18	46 7	46 55	47 43	2 1·6
3 2	40	42 1	42 49	43 37	44 25	45 13	46 1	46 50	47 38	3 2·4
4 2	50	41 55	42 43	43 31	44 19	45 7	45 55	46 43	47 31	4 3·2
5 3	37 0	41 51	42 39	43 26	44 14	45 2	45 50	46 38	47 26	5 4·0
6 3	10	41 45	42 33	43 21	44 8	44 56	45 44	46 32	47 20	6 4·8
7 4	20	41 40	42 28	43 16	44 3	44 51	45 39	46 27	47 14	7 5·6
8 4	30	41 34	42 22	43 10	43 57	44 45	45 33	46 20	47 7	8 6·4
9 5	40	41 30	42 17	43 5	43 52	44 40	45 27	46 14	47 2	9 7·2
	50	41 24	42 11	42 59	43 46	44 34	45 21	46 8	46 56	
	38 0	41 19	42 6	42 54	43 41	44 28	45 15	46 3	46 51	
′ ″	10	41 14	42 0	42 48	43 35	44 22	45 9	45 56	46 44	′ ″
1 1	20	41 8	41 54	42 42	43 29	44 16	45 3	45 50	46 37	1 0·8
2 1	30	41 2	41 48	42 36	43 23	44 9	44 56	45 44	46 30	2 1·6
3 2	40	40 57	41 43	42 30	43 18	44 4	44 51	45 38	46 25	3 2·3
4 2	50	40 51	41 37	42 24	43 11	43 58	44 45	45 31	46 18	4 3·1
5 3	39 0	40 46	41 32	42 19	43 6	43 52	44 39	45 26	46 13	5 3·9
6 3	10	40 40	41 26	42 13	42 59	43 46	44 33	45 19	46 5	6 4·7
7 4	20	40 35	41 21	42 8	42 54	43 41	44 27	45 14	46 0	7 5·5
8 4	30	40 29	41 15	42 2	42 48	43 34	44 21	45 7	45 53	8 6·2
9 5	40	40 24	41 10	41 57	42 43	43 29	44 15	45 1	45 48	9 7·0
	50	40 18	41 4	41 50	42 36	43 22	44 9	44 54	45 30	
	40 0	40 13	40 59	41 45	42 31	43 17	44 3	44 49	45 35	
′ ″	10	40 7	40 53	41 38	42 25	43 10	43 56	44 42	45 28	′ ″
1 1	20	40 1	40 47	41 32	42 18	43 4	43 49	44 35	45 21	1 0·8
2 1	30	39 55	40 40	41 26	42 11	42 57	43 43	44 28	45 14	2 1·5
3 2	40	39 49	40 35	41 21	42 6	42 51	43 37	44 23	45 8	3 2·3
4 2	50	39 44	40 29	41 14	42 0	42 45	43 30	44 16	45 1	4 3·0
5 3	41 0	39 38	40 24	41 9	41 54	42 39	43 25	44 10	44 55	5 3·8
6 4	10	39 32	40 17	41 3	41 48	42 33	43 18	44 3	44 48	6 4·5
7 4	20	39 27	40 12	40 57	41 42	42 27	43 12	43 57	44 42	7 5·3
8 5	30	39 21	40 5	40 50	41 35	42 20	43 5	43 50	44 35	8 6·0
9 5	40	39 15	40 0	40 45	41 30	42 15	42 59	43 44	44 29	9 6·8
	50	39 9	39 54	40 39	41 23	42 8	42 53	43 38	44 22	

TABLE XVII.—Correction of the Moon's Altitude.

P. P. for Alt.	Moon's App. Alt.	Moon's Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	P. P. for Par.
	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	
′ ″	42 0	39 3	39 47	40 32	41 17	42 1	42 46	43 30	44 15	
—	10	38 56	39 41	40 26	41 10	41 54	42 39	43 23	44 8	′ ″
1 1	20	38 51	39 36	40 20	41 4	41 49	42 33	43 17	44 1	1 0·7
2 1	30	38 45	39 29	40 13	40 57	41 42	42 26	43 10	43 54	2 1·5
3 2	40	38 40	39 25	40 8	40 52	41 36	42 20	43 4	43 48	3 2·2
4 3	50	38 33	39 17	40 1	40 45	41 29	42 13	42 57	43 41	4 2·9
5 3	43 0	38 27	39 11	39 56	40 39	41 23	42 7	42 51	43 35	5 3·6
6 4	10	38 21	39 5	39 48	40 32	41 16	42 0	42 44	43 27	6 4·4
7 5	20	38 15	38 59	39 42	40 26	41 9	41 53	42 36	43 20	7 5·1
8 5	30	38 8	38 52	39 35	40 19	41 2	41 46	42 29	43 13	8 5·8
9 6	40	38 3	38 46	39 30	40 13	40 57	41 40	42 23	43 7	9 6·6
	50	37 56	38 39	39 23	40 6	40 49	41 33	42 16	42 59	
	44 0	37 50	38 34	39 17	40 0	40 43	41 26	42 10	42 53	
′ ″	10	37 44	38 27	39 10	39 53	40 36	41 19	42 2	42 46	′ ″
1 1	20	37 38	38 20	39 4	39 46	40 29	41 12	41 55	42 38	1 0·7
2 1	30	37 31	38 14	38 56	39 40	40 22	41 5	41 48	42 31	2 1·4
3 2	40	37 26	38 8	38 51	39 33	40 16	40 59	41 41	42 24	3 2·1
4 3	50	37 18	38 1	38 44	39 26	40 9	40 51	41 34	42 17	4 2·8
5 3	45 0	37 13	37 55	38 38	39 21	40 3	40 45	41 28	42 10	5 3·5
6 4	10	37 7	37 49	38 31	39 14	39 56	40 39	41 21	42 3	6 4·2
7 5	20	37 0	37 42	38 24	39 6	39 48	40 31	41 13	41 55	7 4·9
8 5	30	36 53	37 35	38 17	38 59	39 41	40 23	41 5	41 48	8 5·6
9 6	40	36 47	37 29	38 11	38 53	39 35	40 17	40 59	41 41	9 6·3
	50	36 40	37 22	38 4	38 46	39 28	40 10	40 51	41 33	
	46 0	36 35	37 17	37 58	38 40	39 21	40 3	40 45	41 26	
′ ″	10	36 28	37 9	37 51	38 33	39 14	39 56	40 37	41 19	′ ″
1 1	20	36 21	37 3	37 44	38 26	39 7	39 48	40 30	41 11	1 0·7
2 1	30	36 14	36 56	37 37	38 18	38 59	39 41	40 22	41 3	2 1·4
3 2	40	36 9	36 49	37 31	38 12	38 53	39 34	40 15	40 57	3 2·0
4 3	50	36 1	36 43	37 24	38 5	38 46	39 27	40 8	40 49	4 2·7
5 4	47 0	35 56	36 37	37 17	37 58	38 40	39 20	40 1	40 42	5 3·4
6 4	10	35 49	36 29	37 10	37 51	38 32	39 13	39 53	40 34	6 4·1
7 5	20	35 42	36 23	37 3	37 44	38 25	39 5	39 46	40 26	7 4·8
8 6	30	35 35	36 16	36 56	37 37	38 17	38 58	39 38	40 19	8 5·5
9 6	40	35 29	36 9	36 50	37 30	38 11	38 51	39 32	40 12	9 6·2
	50	35 22	36 2	36 42	37 22	38 3	38 44	39 24	40 4	
	48 0	35 16	35 56	36 36	37 16	37 57	38 37	39 17	39 57	
′ ″	10	35 9	35 49	36 29	37 9	37 49	38 29	39 9	39 49	′ ″
1 1	20	35 2	35 42	36 22	37 1	37 42	38 21	39 1	39 41	1 0·6
2 1	30	34 55	35 34	36 15	36 54	37 34	38 13	38 54	39 33	2 1·3
3 2	40	34 49	35 28	36 8	36 47	37 28	38 7	38 47	39 24	3 1·9
4 3	50	34 42	35 21	36 1	36 40	37 20	37 59	38 39	39 18	4 2·6
5 4	49 0	34 35	35 14	35 53	36 33	37 12	37 52	38 31	39 10	5 3·2
6 4	10	34 28	35 7	35 46	36 25	37 4	37 44	38 23	39 2	6 3·9
7 5	20	34 21	35 0	35 39	36 18	36 58	37 37	38 16	38 55	7 4·6
8 6	30	34 14	34 53	35 32	36 11	36 50	37 29	38 8	38 47	8 5·2
9 6	40	34 7	34 46	35 26	36 4	36 43	37 22	38 1	38 40	9 5·9
	50	34 1	34 40	35 18	35 57	36 36	37 15	37 53	38 32	

TABLE XVII.—Correction of the Moon's Altitude.

P. P. for Alt.	Moon's App. Alt.	Moon's Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	P. P. for Par.
	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	
′ ″	50 0	33 54	34 32	35 11	35 49	36 28	37 6	37 45	38 24	
—	10	33 46	34 25	35 3	35 42	36 20	36 58	37 37	38 15	′ ″
1 1	20	33 40	34 19	34 57	35 35	36 13	36 52	37 30	38 8	1 0·6
2 2	30	33 33	34 11	34 49	35 28	36 5	36 44	37 22	38 0	2 1·2
3 2	40	33 26	34 4	34 41	35 20	35 58	36 36	37 14	37 52	3 1·9
4 3	50	33 19	33 57	34 35	35 13	35 51	36 29	37 6	37 45	4 2·5
5 4	51 0	33 12	33 50	34 27	35 5	35 43	36 21	36 59	37 36	5 3·1
6 5	10	33 5	33 42	34 20	34 57	35 35	36 13	36 51	37 28	6 3·8
7 5	20	32 58	33 36	34 13	34 51	35 28	36 6	36 43	37 21	7 4·5
8 6	30	32 51	33 28	34 6	34 43	35 21	35 58	36 35	37 12	8 5·1
9 7	40	32 43	33 21	33 57	34 35	35 12	35 49	36 27	37 4	9 5·7
	50	32 36	33 13	33 51	34 27	35 4	35 42	36 19	36 56	
	52 0	32 29	33 6	33 43	34 19	34 57	35 33	36 10	36 48	
′ ″	10	32 21	32 58	33 35	34 12	34 49	35 25	36 2	36 40	′ ″
1 1	20	32 15	32 52	33 28	34 5	34 41	35 18	35 55	36 32	1 0·6
2 2	30	32 7	32 44	33 20	33 57	34 34	35 10	35 47	36 23	2 1·2
3 2	40	32 0	32 36	33 13	33 49	34 25	35 2	35 39	36 14	3 1·8
4 3	50	31 53	32 30	33 6	33 42	34 18	34 54	35 31	36 7	4 2·4
5 4	53 0	31 46	32 22	32 58	33 34	34 11	34 47	35 23	35 59	5 3·0
6 5	10	31 38	32 14	32 50	33 26	34 2	34 38	35 14	35 50	6 3·6
7 5	20	31 32	32 7	32 43	33 19	33 55	34 31	35 7	35 43	7 4·2
8 6	30	31 24	32 0	32 36	33 11	33 47	34 22	34 58	35 34	8 4·8
9 7	40	31 16	31 52	32 28	33 3	33 39	34 15	34 50	35 25	9 5·4
	50	31 10	31 46	32 21	32 56	33 32	34 7	34 43	35 18	
	54 0	31 2	31 38	32 13	32 48	33 23	33 59	34 34	35 9	
′ ″	10	30 55	31 30	32 5	32 40	33 15	33 50	34 26	35 1	′ ″
1 1	20	30 47	31 22	31 57	32 32	33 7	33 43	34 17	34 52	1 0·6
2 2	30	30 40	31 14	31 49	32 24	32 59	33 34	34 8	34 43	2 1·2
3 2	40	30 32	31 7	31 41	32 16	32 50	33 25	34 0	34 35	3 1·7
4 3	50	30 25	31 0	31 34	32 9	32 44	33 18	33 53	34 27	4 2·3
5 4	55 0	30 17	30 52	31 26	32 0	32 35	33 9	33 44	34 18	5 2·9
6 5	10	30 9	30 44	31 18	31 53	32 27	33 1	33 35	34 9	6 3·4
7 6	20	30 3	30 37	31 11	31 45	32 19	32 54	33 28	34 2	7 4·0
8 6	30	29 55	30 29	31 3	31 37	32 11	32 45	33 19	33 53	8 4·6
9 7	40	29 48	30 21	30 55	31 29	32 3	32 37	33 10	33 44	9 5·1
	50	29 41	30 14	30 48	31 22	31 55	32 29	33 3	33 37	
	56 0	29 33	30 7	30 40	31 13	31 47	32 20	32 54	33 28	
′ ″	10	29 25	29 58	30 32	31 5	31 38	32 12	32 46	33 19	′ ″
1 1	20	29 17	29 50	30 23	30 57	31 30	32 4	32 37	33 10	1 0·5
2 2	30	29 9	29 43	30 16	30 49	31 22	31 55	32 28	33 1	2 1·1
3 2	40	29 1	29 34	30 7	30 41	31 13	31 46	32 19	32 52	3 1·6
4 3	50	28 54	29 27	30 0	30 33	31 6	31 39	32 11	32 44	4 2·1
5 4	57 0	28 47	29 20	29 52	30 24	30 57	31 30	32 3	32 35	5 2·7
6 5	10	28 39	29 11	29 44	30 17	30 49	31 21	31 54	32 26	6 3·2
7 6	20	28 32	29 4	29 37	30 9	30 41	31 14	31 46	32 18	7 3·7
8 6	30	28 24	28 56	29 28	30 1	30 33	31 5	31 37	32 10	8 4·2
9 7	40	28 16	28 48	29 20	29 52	30 24	30 57	31 28	32 1	9 4·8
	50	28 9	28 41	29 13	29 45	30 17	30 49	31 20	31 53	

TABLE XVII.—Correction of the Moon's Altitude.

P. P. for Alt.	Moon's App. Alt.	Moon's Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	P. P. for Par.
′ ″	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	
	58 0	28 1	28 33	29 5	29 37	30 8	30 40	31 12	31 44	
—	10	27 53	28 25	28 56	29 28	29 59	30 31	31 3	31 34	′ ″
1 1	20	27 45	28 16	28 48	29 19	29 51	30 22	30 54	31 25	1 0·5
2 2	30	27 37	28 8	28 40	29 11	29 42	30 14	30 45	31 16	2 1·0
3 3	40	27 29	28 0	28 31	29 2	29 34	30 5	30 36	31 7	3 1·5
4 3	50	27 22	27 53	28 24	28 55	29 26	29 57	30 28	30 59	4 2·1
5 4	59 0	27 14	27 45	28 15	28 47	29 17	29 48	30 19	30 50	5 2·6
6 5	10	27 6	27 36	28 7	28 38	29 9	29 39	30 10	30 41	6 3·1
7 6	20	26 58	27 29	28 0	28 30	29 1	29 31	30 2	30 33	7 3·6
8 7	30	26 51	27 21	27 51	28 22	28 52	29 22	29 53	30 24	8 4·1
9 7	40	26 42	27 13	27 43	28 13	28 43	29 14	29 44	30 15	9 4·6
	50	26 34	27 4	27 34	28 4	28 35	29 5	29 35	30 5	
′	60 0	26 26	26 56	27 26	27 56	28 26	28 56	29 26	29 56	
′ ″	10	26 18	26 48	27 18	27 48	28 17	28 47	29 17	29 47	′ ″
1 1	20	26 11	26 40	27 10	27 40	28 10	28 39	29 9	29 38	1 0·5
2 2	30	26 2	26 32	27 2	27 31	28 1	28 30	29 0	29 29	2 1·0
3 3	40	25 54	26 23	26 53	27 22	27 52	28 21	28 50	29 20	3 1·4
4 3	50	25 47	26 16	26 45	27 15	27 44	28 13	28 42	29 12	4 1·9
5 4	61 0	25 39	26 8	26 37	27 6	27 35	28 4	28 33	29 2	5 2·4
6 5	10	25 30	25 59	26 29	26 57	27 26	27 55	28 24	28 53	6 2·9
7 6	20	25 22	25 51	26 20	26 48	27 17	27 46	28 15	28 44	7 3·4
8 7	30	25 14	25 42	26 11	26 40	27 9	27 37	28 6	28 35	8 3·8
9 8	40	25 6	25 34	26 2	26 31	27 0	27 28	27 57	28 25	9 4·3
	50	24 58	25 27	25 55	26 24	26 52	27 20	27 48	28 16	
	62 0	24 50	25 18	25 46	26 15	26 43	27 11	27 39	28 7	
′ ″	10	24 42	25 10	25 38	26 6	26 34	27 2	27 30	27 58	′ ″
1 1	20	24 34	25 2	25 30	25 58	26 26	26 54	27 22	27 49	1 0·4
2 2	30	24 26	24 54	25 22	25 49	26 17	26 44	27 12	27 40	2 0·9
3 3	40	24 17	24 45	25 13	25 40	26 8	26 35	27 3	27 31	3 1·3
4 4	50	24 10	24 37	25 4	25 32	25 59	26 26	26 53	27 21	4 1·8
5 4	63 0	24 1	24 28	24 55	25 23	25 50	26 17	26 44	27 11	5 2·2
6 5	10	23 53	24 20	24 47	25 14	25 41	26 8	26 35	27 2	6 2·7
7 6	20	23 45	24 12	24 39	25 6	25 33	26 0	26 27	26 54	7 3·1
8 7	30	23 36	24 3	24 30	24 57	25 24	25 51	26 17	26 44	8 3·6
9 8	40	23 28	23 55	24 21	24 48	25 15	25 41	26 8	26 35	9 4·0
	50	23 21	23 47	24 14	24 40	25 7	25 33	26 0	26 26	
	64 0	23 12	23 39	24 5	24 31	24 58	25 24	25 50	26 16	
′ ″	10	23 4	23 30	23 56	24 22	24 48	25 16	25 41	26 7	′ ″
1 1	20	22 55	23 21	23 48	24 13	24 39	25 5	25 31	25 57	1 0·4
2 2	30	22 47	23 13	23 39	24 4	24 30	24 56	25 22	25 48	2 0·8
3 3	40	22 39	23 4	23 30	23 55	24 21	24 47	25 12	25 38	3 1·2
4 4	50	22 31	22 56	23 22	23 47	24 13	24 38	25 4	25 29	4 1·7
5 4	65 0	22 22	22 47	23 13	23 38	24 4	24 29	24 55	25 20	5 2·1
6 5	10	22 14	22 39	23 4	23 29	23 55	24 20	24 45	25 10	6 2·5
7 6	20	22 5	22 30	22 55	23 20	23 46	24 10	24 35	25 1	7 2·9
8 7	30	21 56	22 22	22 46	23 11	23 36	24 1	24 26	24 51	8 3·3
9 8	40	21 48	22 13	22 37	23 2	23 27	23 52	24 16	24 41	9 3·7
	50	21 41	22 5	22 30	22 54	23 18	23 43	24 8	24 32	

TABLE XVII.—Correction of the Moon's Altitude.

P. P. for Alt.	Moon's App. Alt.	Moon's Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	P. P. for Par.
′ ″	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	
	66 0	21 32	21 56	22 21	22 45	23 9	23 34	23 58	24 23	
—	10	21 23	21 48	22 12	22 36	23 0	23 24	23 48	24 13	′ ″
1 1	20	21 16	21 40	22 4	22 28	22 52	23 16	23 40	24 4	1 0·4
2 2	30	21 7	21 31	21 55	22 19	22 43	23 7	23 31	23 54	2 0·8
3 3	40	20 58	21 22	21 46	22 10	22 33	22 57	23 21	23 45	3 1·1
4 4	50	20 49	21 13	21 37	22 0	22 24	22 48	23 11	23 35	4 1·5
5 5	67 0	20 41	21 4	21 28	21 51	22 15	22 38	23 1	23 25	5 1·9
6 5	10	20 32	20 55	21 19	21 42	22 6	22 29	22 52	23 15	6 2·3
7 6	20	20 25	20 48	21 11	21 34	21 57	22 20	22 43	23 7	7 2·7
8 7	30	20 16	20 39	21 2	21 25	21 48	22 11	22 34	22 56	8 3·0
9 8	40	20 7	20 30	20 53	21 16	21 38	22 1	22 24	22 47	9 3·4
	50	19 58	20 21	20 44	21 7	21 29	21 52	22 14	22 37	
	68 0	19 50	20 12	20 35	20 57	21 20	21 42	22 5	22 27	
′ ″	10	19 41	20 3	20 26	20 48	21 11	21 32	21 55	22 17	′ ″
1 1	20	19 33	19 56	20 18	20 39	21 2	21 24	21 46	22 8	1 0·4
2 2	30	19 24	19 47	20 8	20 30	20 53	21 14	21 36	21 59	2 0·7
3 3	40	19 15	19 38	19 59	20 21	20 43	21 3	21 25	21 49	3 1·1
4 4	50	19 8	19 30	19 51	20 13	20 34	20 56	21 18	21 40	4 1·5
5 5	69 0	18 59	19 21	19 42	20 4	20 25	20 46	21 8	21 30	5 1·8
6 6	10	18 51	19 12	19 33	19 54	20 16	20 36	20 58	21 19	6 2·2
7 6	20	18 42	19 3	19 24	19 45	20 6	20 27	20 49	21 10	7 2·5
8 7	30	18 33	18 54	19 15	19 36	19 57	20 18	20 39	21 0	8 2·9
9 8	40	18 24	18 45	19 6	19 27	19 46	20 8	20 29	20 50	9 3·3
	50	18 16	18 37	18 58	19 18	19 39	19 59	20 20	20 41	
	70 0	18 7	18 28	18 48	19 9	19 29	19 50	20 10	20 31	
′ ″	10	17 58	18 19	18 39	18 59	19 20	19 40	20 1	20 21	′ ″
1 1	20	17 49	18 10	18 30	18 50	19 10	19 31	19 50	20 11	1 0·3
2 2	30	17 41	18 1	18 20	18 41	19 1	19 20	19 41	20 1	2 0·7
3 3	40	17 33	17 53	18 12	18 32	18 52	19 12	19 32	19 51	3 1·0
4 4	50	17 24	17 44	18 3	18 23	18 42	19 2	19 22	19 42	4 1·3
5 5	71 0	17 15	17 35	17 54	18 14	18 33	18 53	19 12	19 32	5 1·7
6 6	10	17 6	17 25	17 45	18 4	18 23	18 43	19 2	19 21	6 2·0
7 6	20	16 57	17 16	17 35	17 54	18 14	18 33	18 52	19 11	7 2·3
8 7	30	16 48	17 7	17 26	17 45	18 4	18 23	18 42	19 2	8 2·6
9 8	40	16 40	16 59	17 18	17 37	17 55	18 15	18 33	18 52	9 3·0
	50	16 31	16 50	17 9	17 27	17 46	18 5	18 24	18 42	
	72 0	16 22	16 41	16 59	17 18	17 36	17 55	18 13	18 32	
′ ″	10	16 13	16 31	16 50	17 9	17 27	17 45	18 3	18 22	′ ″
1 1	20	16 4	16 22	16 41	16 59	17 17	17 36	17 54	18 12	1 0·3
2 2	30	15 55	16 13	16 31	16 49	17 7	17 25	17 43	18 1	2 0·6
3 3	40	15 47	16 5	16 23	16 41	16 59	17 17	17 35	17 52	3 0·9
4 4	50	15 38	15 56	16 14	16 31	16 49	17 7	17 25	17 42	4 1·2
5 5	73 0	15 29	15 47	16 4	16 22	16 40	16 57	17 14	17 32	5 1·5
6 6	10	15 20	15 38	15 55	16 13	16 30	16 47	17 5	17 22	6 1·8
7 7	20	15 11	15 28	15 46	16 3	16 20	16 37	16 55	17 12	7 2·1
8 8	30	15 2	15 19	15 36	15 53	16 10	16 28	16 44	17 2	8 2·4
9 9	40	14 54	15 11	15 28	15 45	16 2	16 18	16 35	16 52	9 2·7
	50	14 45	15 2	15 18	15 35	15 52	16 9	16 26	16 42	

TABLE XVII.—Correction of the Moon's Altitude.

P. P. for Alt.	Moon's App. Alt.	Moon's Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	P. P. Par.
	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	
′ ″	74 0	14 36	14 53	15 9	15 26	15 42	15 59	16 15	16 32	
—	10	14 27	14 44	15 0	15 16	15 32	15 49	16 5	16 21	′ ″
1 1	20	14 18	14 34	14 50	15 6	15 23	15 39	15 55	16 11	1 0·3
2 2	30	14 9	14 25	14 41	14 57	15 13	15 29	15 45	16 1	2 0·5
3 3	40	14 1	14 16	14 33	14 48	15 4	15 20	15 36	15 52	3 0·8
4 4	50	13 52	14 7	14 23	14 39	14 54	15 10	15 26	15 42	4 1·1
5 5	75 0	13 43	13 58	14 13	14 29	14 45	15 0	15 16	15 31	5 1·3
6 6	10	13 33	13 49	14 4	14 19	14 35	14 50	15 6	15 21	6 1·6
7 7	20	13 24	13 40	13 55	14 10	14 25	14 40	14 55	15 10	7 1·8
8 8	30	13 15	13 30	13 45	14 0	14 15	14 30	14 45	15 0	8 2·1
9 9	40	13 7	13 22	13 37	13 52	14 7	14 22	14 36	14 51	9 2·4
	50	12 58	13 13	13 28	13 42	13 57	14 11	14 26	14 41	
	76 0	12 49	13 4	13 18	13 32	13 47	14 1	14 16	14 31	
′ ″	10	12 40	12 54	13 8	13 23	13 37	13 52	14 6	14 20	′ ″
1 1	20	12 31	12 44	12 59	13 13	13 27	13 41	13 56	14 10	1 0·2
2 2	30	12 22	12 35	12 49	13 4	13 17	13 31	13 46	13 59	2 0·5
3 3	40	12 13	12 27	12 41	12 55	13 9	13 23	13 36	13 50	3 0·7
4 4	50	12 4	12 18	12 32	12 45	12 59	13 12	13 26	13 39	4 0·9
5 5	77 0	11 55	12 8	12 22	12 35	12 49	13 2	13 16	13 29	5 1·1
6 6	10	11 45	11 59	12 12	12 26	12 40	12 53	13 7	13 20	6 1·4
7 7	20	11 37	11 51	12 3	12 16	12 30	12 43	12 57	13 10	7 1·6
8 8	30	11 28	11 41	11 54	12 7	12 21	12 34	12 47	13 0	8 1·8
9 9	40	11 19	11 32	11 45	11 58	12 11	12 24	12 37	12 49	9 2·1
	50	11 11	11 23	11 36	11 49	12 1	12 14	12 26	12 39	
	78 0	11 2	11 14	11 26	11 39	11 51	12 4	12 16	12 29	
′ ″	10	10 52	11 5	11 17	11 29	11 42	11 54	12 6	12 19	′ ″
1 1	20	10 43	10 55	11 8	11 20	11 32	11 44	11 56	12 8	1 0·2
2 2	30	10 34	10 46	10 58	11 10	11 22	11 34	11 46	11 58	2 0·4
3 3	40	10 26	10 38	10 49	11 1	11 12	11 24	11 36	11 48	3 0·6
4 4	50	10 17	10 28	10 39	10 51	11 3	11 14	11 26	11 38	4 0·8
5 5	79 0	10 7	10 18	10 30	10 41	10 53	11 4	11 16	11 27	5 1·0
6 6	10	9 58	10 9	10 21	10 32	10 43	10 54	11 6	11 17	6 1·2
7 7	20	9 48	10 0	10 11	10 22	10 33	10 44	10 56	11 7	7 1·4
8 8	30	9 39	9 50	10 2	10 13	10 24	10 35	10 46	10 57	8 1·6
9 9	40	9 31	9 42	9 52	10 3	10 14	10 25	10 35	10 46	9 1·8
	50	9 22	9 33	9 43	9 53	10 4	10 15	10 25	10 36	
	80 0	9 13	9 23	9 33	9 44	9 54	10 5	10 15	10 25	
′ ″	10	9 3	9 14	9 24	9 34	9 44	9 55	10 5	10 15	′ ″
1 1	20	8 54	9 4	9 15	9 25	9 35	9 45	9 55	10 5	1 0·2
2 2	30	8 45	8 55	9 5	9 15	9 25	9 35	9 45	9 55	2 0·3
3 3	40	8 36	8 46	8 56	9 5	9 15	9 25	9 34	9 44	3 0·5
4 4	50	8 27	8 37	8 46	8 56	9 5	9 15	9 24	9 34	4 0·6
5 5	81 0	8 18	8 27	8 37	8 46	8 55	9 5	9 14	9 24	5 0·8
6 6	10	8 9	8 18	8 27	8 36	8 45	8 55	9 4	9 13	6 1·0
7 7	20	8 0	8 9	8 18	8 27	8 36	8 45	8 54	9 3	7 1·1
8 8	30	7 50	7 59	8 8	8 17	8 26	8 35	8 44	8 52	8 1·3
9 9	40	7 41	7 50	7 59	8 7	8 16	8 25	8 33	8 42	9 1·5
	50	7 32	7 41	7 49	7 58	8 6	8 15	8 23	8 32	

TABLE XVII.—Correction of the Moon's Altitude.

P. P. for Alt.	Moon's App. Alt.	Moon's Horizontal Parallax 54′	55′	56′	57′	58′	59′	60′	61′	P. P. for Par.
	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	
′ ″	82 0	7 23	7 31	7 40	7 48	7 56	8 5	8 13	8 21	
—	10	7 14	7 22	7 30	7 38	7 46	7 55	8 3	8 11	′ ″
1 1	20	7 5	7 13	7 21	7 29	7 37	7 45	7 53	8 1	1 0·1
2 2	30	6 55	7 3	7 11	7 19	7 27	7 35	7 42	7 50	2 0·3
3 3	40	6 46	6 54	7 2	7 9	7 17	7 25	7 32	7 40	3 0·4
4 4	50	6 37	6 45	6 52	7 0	7 7	7 14	7 22	7 29	4 0·5
5 5	83 0	6 28	6 35	6 42	6 50	6 57	7 4	7 12	7 19	5 0·6
6 6	10	6 19	6 26	6 33	6 40	6 47	6 54	7 2	7 9	6 0·8
7 7	20	6 9	6 16	6 23	6 30	6 37	6 44	6 51	6 58	7 0·9
8 8	30	6 0	6 7	6 14	6 21	6 27	6 34	6 41	6 48	8 1·0
9 9	40	5 51	5 58	6 4	6 11	6 18	6 24	6 31	6 37	9 1·2
	50	5 42	5 48	5 55	6 1	6 8	6 14	6 21	6 27	
	84 0	5 33	5 39	5 45	5 52	5 58	6 4	6 10	6 17	
′ ″	10	5 23	5 30	5 36	5 42	5 48	5 54	6 0	6 6	′ ″
1 1	20	5 14	5 20	5 26	5 32	5 38	5 44	5 50	5 56	1 0·1
2 2	30	5 5	5 11	5 17	5 22	5 28	5 34	5 40	5 45	2 0·2
3 3	40	4 56	5 1	5 7	5 13	5 18	5 24	5 29	5 35	3 0·3
4 4	50	4 47	4 52	4 57	5 3	5 8	5 14	5 19	5 24	4 0·4
5 5	85 0	4 37	4 43	4 48	4 53	4 58	5 4	5 9	5 14	5 0·5
6 6	10	4 28	4 33	4 38	4 43	4 48	4 53	4 59	5 4	6 0·6
7 7	20	4 19	4 24	4 29	4 34	4 38	4 43	4 48	4 53	7 0·6
8 8	30	4 10	4 14	4 19	4 24	4 29	4 33	4 38	4 43	8 0·7
9 9	40	4 0	4 5	4 10	4 14	4 19	4 23	4 28	4 32	9 0·8
	50	3 51	3 56	4 0	4 4	4 9	4 13	4 17	4 22	
	86 0	3 42	3 46	3 50	3 55	3 59	4 3	4 7	4 11	
′ ″	10	3 33	3 37	3 41	3 45	3 49	3 53	3 57	4 1	′ ″
1 1	20	3 24	3 27	3 31	3 35	3 39	3 43	3 47	3 50	1 0·1
2 2	30	3 14	3 18	3 22	3 25	3 29	3 33	3 36	3 40	2 0·1
3 3	40	3 5	3 9	3 12	3 16	3 19	3 23	3 26	3 30	3 0·2
4 4	50	2 56	2 59	3 2	3 6	3 9	3 12	3 16	3 19	4 0·2
5 5	87 0	2 46	2 50	2 53	2 56	2 59	3 2	3 5	3 9	5 0·3
6 6	10	2 37	2 40	2 43	2 46	2 49	2 52	2 55	2 58	6 0·4
7 7	20	2 28	2 31	2 34	2 36	2 39	2 42	2 45	2 48	7 0·4
8 8	30	2 19	2 21	2 24	2 27	2 29	2 32	2 35	2 37	8 0·5
9 9	40	2 10	2 12	2 14	2 17	2 19	2 22	2 24	2 27	9 0·5
	50	2 0	2 3	2 5	2 7	2 9	2 12	2 14	2 16	
	88 0	1 51	1 53	1 55	1 57	1 59	2 2	2 4	2 6	
′ ″	10	1 42	1 44	1 46	1 48	1 50	1 51	1 53	1 55	′ ″
1 1	20	1 33	1 34	1 36	1 38	1 40	1 41	1 43	1 45	1 0·0
2 2	30	1 23	1 25	1 26	1 28	1 30	1 31	1 33	1 34	2 0·1
3 3	40	1 14	1 15	1 17	1 18	1 20	1 21	1 22	1 24	3 0·1
4 4	50	1 5	1 6	1 7	1 8	1 10	1 11	1 12	1 13	4 0·1
5 5	89 0	0 56	0 57	0 58	0 59	1 0	1 1	1 2	1 3	5 0·1
6 6	10	0 46	0 47	0 48	0 49	0 50	0 51	0 52	0 52	6 0·2
7 7	20	0 37	0 38	0 38	0 39	0 40	0 41	0 41	0 42	7 0·2
8 8	30	0 28	0 28	0 29	0 29	0 30	0 30	0 31	0 31	8 0·2
9 9	40	0 18	0 19	0 19	0 20	0 20	0 20	0 21	0 21	9 0·2
	50	0 9	0 9	0 10	0 10	0 10	0 10	0 10	0 10	

TABLE XVIII.

Logarithms for finding the Horary Angle or Apparent Time.

Min.	2 Hours.	Diff.	3 Hours.	Diff.	4 Hours.	Diff.	5 Hours.	Diff.	6 Hours.	Diff.	7 Hours.	Diff.	
0	8·825992	11737	9·165679	7602	9·397940	5457	9·568894	4107	9·698970	3152	9·798933	2418	60
1	833034	11635	170240	7555	401214	5428	571358	4088	700861	3138	800384	2407	59
2	840015	11535	174773	7509	404471	5401	573811	4070	702743	3124	801828	2396	58
3	846936	11437	179278	7463	407713	5375	576253	4052	704618	3110	803266	2385	57
4	853798	11340	183756	7418	410938	5348	578684	4033	706484	3097	804697	2375	56
5	8·860602	11245	9·188207	7373	9·414147	5322	9·581104	4015	9·708342	3083	9·806122	2364	55
6	867349	11152	192631	7329	417340	5296	583513	3997	710192	3070	807540	2353	54
7	874040	11061	197028	7285	420517	5270	585911	3980	712034	3057	808952	2342	53
8	880676	10970	201399	7241	423679	5243	588299	3962	713868	3043	810357	2332	52
9	887258	10880	205745	7198	426825	5217	590676	3944	715694	3030	811756	2321	51
10	8·893785	10792	9·210064	7156	9·429955	5192	9·593042	3927	9·717512	3017	9·813149	2311	50
11	900261	10706	214358	7114	433070	5167	595398	3910	719322	3005	814535	2300	49
12	906684	10620	218627	7073	436170	5142	597744	3892	721124	2992	815915	2289	48
13	913055	10536	222870	7032	439255	5117	600078	3875	722919	2978	817289	2279	47
14	919377	10453	227089	6991	442325	5092	602403	3857	724705	2965	818656	2268	46
15	8·925648	10371	9·231284	6950	9·445379	5067	9·604717	3840	9·726484	2952	9·820017	2258	45
16	931871	10290	235454	6910	448419	5043	607021	3823	728255	2939	821372	2248	44
17	938045	10210	239600	6870	451445	5018	609315	3806	730018	2926	822721	2237	43
18	944171	10132	243722	6831	454455	4993	611598	3790	731774	2913	824063	2227	42
19	950251	10055	247821	6792	457451	4969	613872	3772	733522	2900	825399	2217	41
20	956284		251897		460433		616135		735262		826729		40
	21 Hours.	Diff.	20 Hours.	Diff.	19 Hours.	Diff.	18 Hours.	Diff.	17 Hours.	Diff.	16 Hours.	Diff.	Min.

TABLE XVIII.

LOGARITHMS FOR FINDING THE HORARY ANGLE OR APPARENT TIME.

Min.	2 Hours.	Diff.	3 Hours.	Diff.	4 Hours.	Diff.	5 Hours.	Diff.	6 Hours.	Diff.	7 Hours.	Diff.	Min.
20	8·956284	9979	9·251897	6753	9·460433	4945	9·616135	3756	9·735262	2887	9·826729	2206	40
21	962271	9904	255949	6715	463400	4921	618388	3740	736994	2875	828053	2196	39
22	968213	9830	259978	6678	466354	4898	620632	3721	738719	2863	829370	2186	38
23	974111	9757	263985	6640	469293	4875	622865	3707	740437	2850	830682	2176	37
24	979965	9684	267969	6602	472218	4852	625089	3690	742147	2837	831987	2166	36
25	8·985775	9612	9·271930	6566	9·475129	4828	9·627303	3674	9·743849	2825	9·833287	2155	35
26	991543	9543	275870	6530	478026	4805	629507	3658	745544	2813	834580	2145	34
27	997269	9474	279788	6493	480909	4782	631701	3642	747232	2800	835867	2135	33
28	9·002953	9405	283684	6457	483779	4760	633886	3626	748912	2788	837148	2125	32
29	008596	9338	287558	6422	486635	4738	636061	3610	750585	2776	838424	2115	31
30	9·014198	9272	9·291412	6387	9·489478	4715	9·638227	3593	9·752251	2763	9·839693	2105	30
31	019761	9206	295244	6352	492307	4693	640383	3577	753909	2750	840956	2095	29
32	025284	9141	299055	6317	495123	4672	642529	3562	755560	2738	842213	2085	28
33	030768	9077	302845	6283	497926	4650	644666	3547	757203	2727	843464	2076	27
34	036213	9013	306615	6249	500716	4628	646794	3532	758840	2715	844710	2066	26
35	9·041621	8950	310364	6216	9·503492	4607	9·648913	3516	9·760469	2703	9·845949	2056	25
36	046991	8888	314094	6182	506256	4585	651022	3500	762091	2692	847183	2046	24
37	052323	8827	317803	6148	509007	4563	653122	3485	763706	2680	848410	2036	23
38	057619	8767	321492	6115	511745	4542	655213	3469	765314	2668	849632	2027	22
39	062879	8707	325161	6083	514470	4521	657294	3455	766914	2657	850848	2017	21
40	068103		328811		517183		659367		768508		852058		20
	21 Hours.	Diff.	20 Hours.	Diff.	19 Hours.	Diff.	18 Hours.	Diff.	17 Hours.	Diff.	16 Hours.	Diff.	Min.

TABLE XVIII.

LOGARITHMS FOR FINDING THE HORARY ANGLE OR APPARENT TIME.

Min.	2 Hours.	Diff.	3 Hours.	Diff.	4 Hours.	Diff.	5 Hours.	Diff.	6 Hours.	Diff.	7 Hours.	Diff.		Min.
													20	
40	9·068103	8648	9·328811	6052	9·517183	4500	9·659367	3440	9·768508	2645	9·852058	2007	19	
41	073392	8590	332442	6019	519883	4479	661430	3425	770094	2633	853263	1998	18	
42	078446	8532	336053	5987	522570	4458	663485	3409	771674	2622	854461	1988	17	
43	083565	8477	339645	5956	525245	4438	665530	3395	773247	2610	855654	1979	16	
44	088651	8419	343219	5924	527908	4418	667567	3379	774812	2598	856841	1969		
45	9·093702	8363	9·346773	5893	9·530559	4397	9·669594	3365	9·776371	2586	9·858022	1959	15	
46	098720	8308	350309	5863	533197	4377	671613	3350	777922	2575	859198	1949	14	
47	103706	8254	353827	5832	535823	4357	673623	3336	779467	2563	860367	1940	13	
48	108658	8201	357326	5802	538437	4338	675621	3322	781005	2552	861532	1931	12	
49	113579	8148	360807	5772	541040	4318	677617	3307	782536	2541	862690	1921	11	
50	9·118468	8095	9·364270	5742	9·543630	4298	9·679601	3292	9·784061	2530	9·863843	1912	10	
51	123325	8043	367715	5712	546208	4278	681576	3278	785578	2518	864990	1903	9	
52	128151	7992	371142	5683	548775	4258	683543	3263	787089	2507	866131	1893	8	
53	132946	7942	374552	5654	551330	4239	685501	3249	788593	2495	867267	1884	7	
54	137711	7892	377945	5625	553874	4220	687450	3235	790090	2484	868397	1874	6	
55	9·142446	7842	9·381320	5597	9·556406	4200	9·689391	3221	9·791580	2473	9·869522	1865	5	
56	147151	7793	384678	5568	558926	4182	691324	3207	793064	2462	870641	1856	4	
57	151826	7744	388018	5540	561435	4163	693248	3193	794541	2451	871754	1846	3	
58	156473	7696	391342	5512	563933	4144	695163	3179	796012	2440	872862	1837	2	
59	161090	7648	394650	5484	566419	4125	697071	3165	797476	2428	873964	1828	1	
60	165679		397940		568894		698970		798933		875061		0	
	21 Hours.	Diff.	20 Hours.	Diff.	19 Hours.	Diff.	18 Hours.	Diff.	17 Hours.	Diff.	16 Hours.	Diff.		Min.

TABLE XIX.

Common and Hyperbolic Logarithms.

Common Logarithms.	Hyp. Logarithms	Hyperbolic Logarithms.	Com. Logarithms.
1·	2·3025851	1·	·4342945
2·	4·6051702	2·	·8685890
3·	6·9077553	3·	1·3028834
4·	9·2103404	4·	1·7371779
5·	11·5129255	5·	2·1714724
6·	13·8155106	6·	2·6057669
7·	16·1180957	7·	3·0400614
8·	18·4206807	8·	3·4743559
9·	20·7232658	9·	3·9086503

TABLE XX.

Curvature of the Earth and Refraction.

Distance in Chains.	Curvature.	Curvature and Refraction.	Distance in Miles.	Curvature.	Curvature and Refraction.
	Feet.	Feet.		Feet.	Feet.
1	·00010	·00009	1	·67	·57
2	·00042	·00036	2	2·67	2·29
3	·00094	·00080	3	6·00	5·14
4	·00167	·00143	4	10·67	9·15
5	·00261	·00223	5	16·67	14·29
6	·00375	·00322	6	24·00	20·57
7	·00511	·00438	7	32·68	28·01
8	·00667	·00572	8	42·69	36·60
9	·00844	·00724	9	54·02	46·30
10	·01042	·00893	10	66·70	57·17
11	·01261	·01081	11	80·71	69·18
12	·01501	·01286	12	96·05	72·33
13	·01761	·01510	13	112·72	96·62
14	·02043	·01751	14	130·73	112·05
15	·02345	·02010	15	150·08	128·64
16	·02668	·02287	16	170·75	146·36
17	·03012	·02582	17	192·77	165·23
18	·03377	·02894	18	216·10	185·23
19	·03762	·03225	19	240·80	206·40
20	·04169	·03573	20	266·80	228·68
40	·16685	·14302	25	416·88	357·32
60	·37519	·32173	30	600·30	514·83

TABLE XXI.—Trigonometrical Equivalents.

(Arc c = half the arc a.)

(1.) $$\text{Sin } a = \cos a \,.\, \tan a = \frac{\cos a}{\cot a} = \sqrt{1-(\cos a)^2} = \frac{1}{\operatorname{cosec} a}$$
$$= \frac{1}{\sqrt{1+(\cot a)^2}} = \frac{\tan a}{\sqrt{1+(\tan a)^2}} = 2\sin c \,.\, \cos c$$
$$= \sqrt{\frac{1-\cos 2a}{2}} = \frac{2\tan c}{1+(\tan c)^2} = \frac{}{\cot c + \tan c}$$
$$= \frac{1}{\cot a + \tan c} = 2\left\{\sin(45^\circ + c)\right\}^2 - 1 = 1 - 2\left\{\sin(45^\circ - c)\right\}^2$$
$$= \frac{1-\left\{\tan(45^\circ - c)\right\}^2}{1+\left\{\tan(45^\circ - c)\right\}^2} = \sin(60^\circ + a) - \sin(60^\circ - a).$$

(2.) $$\text{Cos } a = \sin a \,.\, \cot a = \frac{\sin a}{\tan a} = \sqrt{1-(\sin a)^2} = \frac{1}{\sec a}$$
$$= \frac{1}{\sqrt{1+(\tan a)^2}} = \frac{\cot a}{\sqrt{1+(\cot a)^2}} = (\cos c)^2 - (\sin c)^2$$
$$= 1 - 2(\sin c)^2 = 2(\cos c)^2 - 1 = \sqrt{\frac{1+\cos 2a}{2}}$$
$$= \frac{1-(\tan c)^2}{1+(\tan c)^2} = \frac{\cot c - \tan c}{\cot c + \tan c} = \frac{1}{1+\tan a \,.\, \tan c}.$$

(3.) $$\text{Tan } a = \frac{\sin a}{\cos a} = \frac{1}{\cot a} = \sqrt{\frac{1}{(\cos a)^2} - 1} = \sqrt{(\sec a)^2 - 1}$$
$$= \frac{\sec a}{\operatorname{cosec} a} = \frac{\sin a}{\sqrt{1-(\sin a)^2}} = \frac{\sin a \,.\, \cos a}{\cot a} = \frac{\sqrt{1-(\cos a)^2}}{\cos a}$$
$$= \frac{2\tan c}{1-(\tan c)^2} = \frac{2\cot c}{(\cot c)^2 - 1} = \frac{2}{\cot c - \tan c} = \frac{1-\cos 2a}{\sin 2a}$$
$$= \cot a - 2\cot 2a = \frac{\sin 2a}{1+\cos 2a} = \sqrt{\frac{1-\cos 2a}{1+\cos 2a}}.$$

(4.) $\text{Cot } a = \sqrt{(\operatorname{cosec} a)^2 - 1} = \dfrac{\cos a}{\sin a} = \dfrac{1}{\tan a}$ = the reciprocals of the above expressions for the tangent.

(5.) $\text{Sec } a = \sqrt{1+(\tan a)^2} = \dfrac{\tan a}{\sin a} = \dfrac{1}{\cos a}$ = the reciprocals of the above expressions for the cosine.

(6.) $\text{Cosec } a = \sqrt{1+(\cot a)^2} = \dfrac{\sec a}{\tan a} = \sec a \,.\, \cot a = \dfrac{1}{\sin a}$ = the reciprocals of the above expressions for the sine.

(7.) $\text{Versin } a = \dfrac{(\sin a)^2}{1+\cos a}$.

(8.) $\text{Coversin } a = \dfrac{(\cos a)^2}{1+\sin a}$.

TABLE XXII.—Expressions for Multiple Arcs.

(1.) $\text{Sin } \frac{1}{2}a = \sqrt{\frac{1-\cos a}{2}}$.

(2.) $\text{Sin } 2a = 2 \sin a \,.\, \cos a$.

(3.) $\text{Sin } 3a = 3 \sin a - 4 (\sin a)^3$.

(4.) $\text{Sin } 4a = \cos a \left\{4 \sin a - 8 (\sin a)^3\right\}$.

(5.) $\text{Sin } 5a = 5 \sin a - 20 (\sin a)^3 + 16 (\sin a)^5$.

(6.) $\text{Sin } na = 2^{n-1} \,.\, \sin \beta \,.\, \sin\left(\beta + \frac{\pi}{n}\right) \,.\, \sin\left(\beta + \frac{2\pi}{n}\right) + \&c.$

(7.) $$= \cos a \left\{(2 \sin a)^{n-1} - \frac{n-2}{1}(2 \sin a)^{n-3} + \frac{(n-3)\,.\,(n-4)}{1\,.\,2}(2 \sin a)^{n-5} - \frac{(n-4)\,.\,(n-5)\,.\,(n-6)}{1\,.\,2\,.\,3}(2 \sin a)^{n-7} + \&c.\right.$$

(8.) $\text{Cos } \frac{1}{2}a = \sqrt{\frac{1+\cos a}{2}}$.

(9.) $\text{Cos } 2a = 2 (\cos a)^2 - 1$.

(10.) $\text{Cos } 3a = 4 (\cos a)^3 - 3 \cos a$.

(11.) $\text{Cos } 4a = 8 (\cos a)^4 - 8 (\cos a)^2 + 1$.

(12.) $\text{Cos } 5a = 16 (\cos a)^5 - 20 (\cos a)^3 + 5 \cos a$.

(13.) $$\text{Cos } na = \tfrac{1}{2}\left\{(2 \sin a)^n - n (2 \sin a)^{n-2} + \frac{n(n-3)}{1\,.\,2}(2 \sin a)^{n-4} - \frac{n(n-4)\,.\,(n-5)}{1\,.\,2\,.\,3}(2 \sin a)^{n-6} + \&c.\right\}.$$

(14.) $\text{Tan } \frac{a}{2} = \frac{\tan a}{1 + \sqrt{1 + (\tan a)^2}}$.

(15.) $\text{Tan } 2a = \frac{2 \tan a}{1 - (\tan a)^2}$.

(16.) $\text{Tan } 3a = \frac{3 \tan a - (\tan a)^3}{1 - 3 (\tan a)^2}$.

(17.) $\text{Tan } 4a = \frac{4 \tan a - 4 (\tan a)^3}{1 - 6 (\tan a)^2 + (\tan a)^4}$.

(18.) $\text{Tan } 5a = \frac{5 \tan a - 10 (\tan a)^3 + (\tan a)^5}{1 - 10 (\tan a)^2 + 5 (\tan a)^4}$.

(19.) $\text{Cot } \frac{a}{2} = \frac{1}{\sqrt{1 + (\cot a)^2} - \cot a}$.

(20.) $\text{Cot } 2a = \frac{(\cot a)^2 - 1}{2 \cot a}$.

(21.) $\text{Cot } 3a = \frac{(\cot a)^3 - 3 \cot a}{3 (\cot a)^2 - 1}$.

(22.) $\text{Cot } 4a = \frac{(\cot a)^4 - 6 (\cot a)^2 + 1}{4 (\cot a)^3 - 4 \cot a}$.

(23.) $\text{Cot } 5a = \frac{(\cot a)^5 - 10 (\cot a)^3 + 5 \cot a}{5 (\cot a)^4 - 10 (\cot a)^2 + 1}$.

TABLE XXIII.—Formulæ relating to two Arcs or Angles.

(1.) $\text{Sin}\,(\alpha+\beta) = \sin\alpha\,.\,\cos\beta + \cos\alpha\,.\,\sin\beta.$

(2.) $\text{Sin}\,(\alpha-\beta) = \sin\alpha\,.\,\cos\beta - \cos\alpha\,.\,\sin\beta.$

(3.) $\text{Cos}\,(\alpha+\beta) = \cos\alpha\,.\,\cos\beta - \sin\alpha\,.\,\sin\beta.$

(4.) $\text{Cos}\,(\alpha-\beta) = \cos\alpha\,.\,\cos\beta + \sin\alpha\,.\,\sin\beta.$

(5.) $\text{Tan}\,(\alpha+\beta) = \dfrac{\tan\alpha+\tan\beta}{1-\tan\alpha\,.\,\tan\beta}.$

(6.) $\text{Tan}\,(\alpha-\beta) = \dfrac{\tan\alpha-\tan\beta}{1+\tan\alpha\,.\,\tan\beta}.$

(7.) $\text{Cot}\,(\alpha+\beta) = \dfrac{\cot\alpha\,.\,\cot\beta-1}{\cot\beta+\cot\alpha}.$

(8.) $\text{Cot}\,(\alpha-\beta) = \dfrac{\cot\alpha\,.\,\cot\beta+1}{\cot\beta-\cot\alpha}.$

(9.) $\text{Sin}\,(\alpha+\beta)\,.\,\sin\,(\alpha-\beta) = (\sin\alpha)^2-(\sin\beta)^2 = (\cos\beta)^2-(\cos\alpha)^2.$

(10.) $\text{Cos}\,(\alpha+\beta)\,.\,\cos\,(\alpha-\beta) = (\cos\alpha)^2-(\sin\beta)^2 = (\cos\beta)^2-(\sin\alpha)^2.$

(11.) $\dfrac{\text{Sin}\,(\alpha+\beta)}{\text{Sin}\,(\alpha-\beta)} = \dfrac{\tan\alpha+\tan\beta}{\tan\alpha-\tan\beta} = \dfrac{\cot\beta+\cot\alpha}{\cot\beta-\cot\alpha}.$

(12.) $\dfrac{\text{Cos}\,(\alpha+\beta)}{\text{Sin}\,(\alpha-\beta)} = \dfrac{\cot\beta-\tan\alpha}{\cot\beta+\tan\alpha} = \dfrac{\cot\alpha-\tan\beta}{\cot\alpha+\tan\beta}.$

(13.) $\text{Sin}\,\alpha+\sin\beta = 2\,\sin\tfrac{1}{2}\,(\alpha+\beta)\,.\,\cos\tfrac{1}{2}\,(\alpha-\beta).$

(14.) $\text{Sin}\,\alpha-\sin\beta = 2\,\sin\tfrac{1}{2}\,(\alpha-\beta)\,.\,\cos\tfrac{1}{2}\,(\alpha+\beta).$

(15.) $\text{Cos}\,\alpha+\cos\beta = 2\,\cos\tfrac{1}{2}\,(\alpha+\beta)\,.\,\cos\tfrac{1}{2}\,(\alpha-\beta).$

(16.) $\text{Cos}\,\alpha-\cos\beta = 2\,\sin\tfrac{1}{2}\,(\alpha-\beta)\,.\,\sin\tfrac{1}{2}\,(\alpha+\beta).$

(17.) $\text{Tan}\,\alpha+\tan\beta = \dfrac{\sin\,(\alpha+\beta)}{\cos\alpha\,.\,\cos\beta}.$

(18.) $\text{Tan}\,\alpha-\tan\beta = \dfrac{\sin\,(\alpha-\beta)}{\cos\alpha\,.\,\cos\beta}$

(19.) $\text{Cot}\,\alpha+\cot\beta = \dfrac{\sin\,(\alpha+\beta)}{\sin\alpha\,.\,\sin\beta}.$

(20.) $\text{Cot}\,\alpha-\cot\beta = \dfrac{\sin\,(\alpha-\beta)}{\sin\alpha\,.\,\sin\beta}.$

(21.) $2\,\sin\alpha\,.\,\cos\beta = \sin\,(\alpha+\beta)+\sin\,(\alpha-\beta).$

(22.) $2\,\cos\alpha\,.\,\sin\beta = \sin\,(\alpha+\beta)-\sin\,(\alpha-\beta).$

(23.) $2\,\cos\alpha\,.\,\cos\beta = \cos\,(\alpha+\beta)+\cos\,(\alpha-\beta).$

(24.) $2\,\sin\alpha\,.\,\sin\beta = \cos\,(\alpha-\beta)-\cos\,(\alpha+\beta).$

(25.) $\text{Tan}\,(\alpha+\beta+\gamma) = \dfrac{\tan\,(\alpha+\beta)+\tan\gamma}{1-\tan\,(\alpha+\beta)\,.\,\tan\gamma}$

$$= \frac{\tan\alpha+\tan\beta+\tan\gamma-\tan\alpha\,.\,\tan\beta\,.\,\tan\gamma}{1-\tan\alpha\,.\,\tan\beta-\tan\alpha\,.\,\tan\beta-\tan\beta\,.\,\tan\gamma}.$$

If $\alpha+\beta+\gamma=\pi$.

(26.) $\text{Tan}\,\alpha+\tan\beta+\tan\gamma = \tan\alpha\,.\,\tan\beta\,.\,\tan\gamma.$

TABLE XXIV.—Trigonometrical Expressions.

Expressions for the sin, cos, tan, and cot, in terms of the arc a.

(1.) $$\text{Sin}\, a = a - \frac{a^3}{1\cdot 2\cdot 3} + \frac{a^5}{1\cdot 2\cdot 3\cdot 4\cdot 5} - \frac{a^7}{1\cdot 2\cdot 3\cdot 4\cdot 5\cdot 6\cdot 7} + \&c.$$
$$= a\left(1 - \frac{a^2}{\pi^2}\right)\cdot\left(1 - \frac{a^2}{4\pi^2}\right)\cdot\left(1 - \frac{a^2}{9\pi^2}\right)\cdot \&c.$$

(2.) $$\text{Cos}\, a = 1 - \frac{a^2}{1\cdot 2} + \frac{a^4}{1\cdot 2\cdot 3\cdot 4} - \frac{a^6}{1\cdot 2\cdot 3\cdot 4\cdot 5\cdot 6} + \&c.$$
$$= \left(1 - \frac{4a^2}{\pi^2}\right)\cdot\left(1 - \frac{4a^2}{9\pi^2}\right)\cdot\left(1 - \frac{4a^2}{25\pi^2}\right)\cdot \&c.$$

(3.) $$\text{Tan}\, a = \frac{8a}{\pi^2 - 4a^2} + \frac{8a}{9\pi^2 - 4a^2} + \frac{8a}{25\pi^2 - 4a^2} + \&c.$$

(4.) $$\text{Cot}\, a = \frac{1}{a} - \frac{2a}{\pi^2 - a^2} - \frac{2a}{4\pi^2 - a^2} - \&c.$$

Expressions for the arc in terms of the sin and tan.

(5.) $$\text{Arc}\, a = \sin a + \frac{(\sin a)^3}{1\cdot 2\cdot 3} + \frac{1\cdot 3\cdot (\sin a)^5}{1\cdot 2\cdot 3\cdot 4\cdot 5} + \&c.$$

(6.) $$\text{Arc}\, a = \tan a - \frac{(\tan a)^3}{3} + \frac{(\tan a)^5}{5} - \&c.$$

Expressions for the powers of the sin and cos.

(7.) $2(\sin a)^2 = 1 - \cos 2a,$

(8.) $4(\sin a)^3 = 3\sin a - \sin 3a,$

(9.) $8(\sin a)^4 = 3 - 4\cos 2a + \cos 4a,$

(10.) $16(\sin a)^5 = \sin 5a - 5\sin 3a + 10\sin a,$

(11.) $$2^n(\sin a)^n = \mp 2\sin na \pm 2n\cdot\sin(n-2)a \mp \frac{2n(n-1)}{1\cdot 2}\sin(n-4)a$$
$$\pm \frac{2n(n-1)\cdot(n-2)}{1\cdot 2\cdot 3}\sin(n-6)a \mp \&c.$$

(12.) Or, $$2^n(\sin a)^n = \pm 2\cos na \mp 2n\cdot\cos(n-2)a \pm \frac{2n(n-1)}{1\cdot 2}\cos(n-4)a$$
$$\mp \frac{2n(n-1)\cdot(n-2)}{1\cdot 2\cdot 3}\cos(n-6)a \pm \&c.$$

When n is of the form $4m + 1$, use series (11) with the upper signs.
" n " $4m - 1$, " (11) " lower signs.
" n " $4m$, " (12) " upper signs.
" n " $4m + 2$, " (12) " lower signs.

(13.) $2(\cos a)^2 = \cos 2a + 1,$

(14.) $4(\cos a)^3 = \cos 3a + 3\cos a,$

(15.) $8(\cos a)^4 = \cos 4a + 4\cos 2a + 3,$

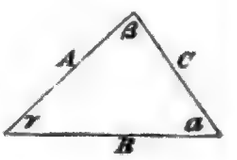
(16.) $16(\cos a)^5 = \cos 5a + 5\cos 3a + 10\cos a.$

(17.) $$2^n(\cos a)^n = 2\cos na + 2n\cdot\cos(n-2)a + \frac{2n(n-1)}{1\cdot 2}\cos(n-4)a$$
$$+ \frac{2n(n-1)\cdot(n-2)}{1\cdot 2\cdot 3}\cos(n-6)a + \&c.$$

The formula ending in $\frac{2n(n-1)\cdot(n-2)\cdot \&c.}{1\cdot 2\cdot 3\cdot \&c.}\cos(n-n)a$, or in $\frac{2n(n-1)\cdot(n-2)\cdot \&c.}{1\cdot 2\cdot 3\cdot \&c.}\cos a$, according as n is an even or an odd number, and in the former case half the expression is to be taken for the last term.

TABLE XXV.—Formulæ for Solving all the Cases of a Rectilineal Triangle, of which three parts are known.

Value of any side, as A.



(1.) $A = \frac{B \cdot \sin a}{\sin \beta}$.

(2.) $= \frac{C \cdot \sin a}{\sin \gamma}$.

(3.) $= \frac{B}{\cos \gamma + \sin \gamma \cdot \cot a}$.

(4.) $= \frac{C}{\cos \beta + \sin \beta \cdot \cot a}$.

(5.) $= B \cdot \cos \gamma + B \cdot \sin \gamma \cdot \cot \beta$.

(6.) $= C \cdot \cos \beta + C \cdot \sin \beta \cdot \cot \gamma$

(7.) $= \sqrt{(B^2 + C^2 - 2B \cdot C \cdot \cos a)}$.

(8.) $= B \cdot \cos \gamma \pm \sqrt{\{C^2 - B^2 \cdot (\sin \gamma)^2\}}$.

(9.) $= C \cdot \cos \beta \pm \sqrt{\{B^2 - C^2 \cdot (\sin \beta)^2\}}$

Value of the sin of any angle, as β.

(10.) $\text{Sin}\,\beta = \frac{B \cdot \sin a}{A}$.

(11.) $= \frac{B \cdot \sin \gamma}{C}$.

(12.) $= \sin (\gamma + a)$.

(13.) $= \sin \gamma \cdot \cos a + \cos \gamma \cdot \sin a$.

(14.) $= \frac{B \cdot \sin a}{\sqrt{B^2 + C^2 - 2B \cdot C \cdot \cos a)}}$.

(15.) $= \frac{B \cdot \sin \gamma}{\sqrt{(B^2 + A^2 - 2B \cdot A \cdot \cos \gamma)}}$.

(16.) $= \sqrt{1 - \left(\frac{A^2 + C^2 - B^2}{2A \cdot C}\right)^2}$.

(17.) $= \frac{\sin a \left\{C \cdot \cos a \pm \sqrt{A^2 - C^2 \cdot (\sin a^2)}\right\}}{A}$.

(18.) $= \frac{\sin \gamma \left\{A \cdot \cos \gamma \pm \sqrt{C^2 - A^2 \cdot (\sin \gamma)^2}\right\}}{C}$.

TABLE XXVI.—Trigonometrical Formulæ for the Solution of Quadratics and Cubics.

Equations of the Second Degree.

If $p^2 < 4q$, x is imaginary.

(1.) $x^2 + px = q$.

Let $\tan a = \frac{2}{p}\sqrt{q}$,

Root $x = \sqrt{q} \cdot \tan \frac{1}{2} a$,

2nd Root $x = -\sqrt{q} \cdot \cot \frac{1}{2} a$.

(2.) $x^2 - px = q$.

$\text{Tan } a = \frac{2}{p}\sqrt{q}$,

$x = -\sqrt{q} \cdot \tan \frac{1}{2} a$,

$x = \sqrt{q} \cdot \cot \frac{1}{2} a$.

(3.) $x^2 + px = -q$.

$\text{Sin } a = \frac{2}{p}\sqrt{q}$,

$x = -\sqrt{q} \cdot \tan \frac{1}{2} a$,

$x = -\sqrt{q} \cdot \cot \frac{1}{2} a$.

(4.) $x^2 - px = -q$.

$\text{Sin } a = \frac{2}{p}\sqrt{q}$,

$x = \sqrt{q} \cdot \tan \frac{1}{2} a$,

$x = \sqrt{q} \cdot \cot \frac{1}{2} a$.

Equations of the Third Degree.

When $4p^3 < 27q^2$.

(5.) $x^3 + px + q = 0$.

Let $\tan a = \frac{p}{3q} 2\sqrt{\frac{p}{3}}$,

Let $\tan \beta = \sqrt[3]{\tan \frac{1}{2} a}$,

Only real root $x = -2\sqrt{\frac{p}{3}} \cdot \cot 2\beta$.

(6.) $x^3 + px - q = 0$.

$\text{Tan } a = \frac{p}{3q} 2\sqrt{\frac{p}{3}}$,

$\tan \beta = \sqrt[3]{\tan \frac{1}{2} a}$,

$x = 2\sqrt{\frac{p}{3}} \cdot \cot 2\beta$.

(7.) $x^3 - px + q = 0$.

$\text{Sin } a = \frac{p}{3q} 2\sqrt{\frac{p}{3}}$,

$\tan a = \sqrt[3]{\tan \frac{1}{2} a}$,

$x = -\frac{2\sqrt{\frac{p}{3}}}{\sin 2\beta}$.

(8.) $x^3 - px - q = 0$.

$\text{Sin } a = \frac{p}{3q} 2\sqrt{\frac{p}{3}}$,

$\tan a = \sqrt[3]{\tan \frac{1}{2} a}$,

$x = \frac{2\sqrt{\frac{p}{3}}}{\sin 2\beta}$.

When $4p^3 >$ or $= 27q^2$, the following will be the solution of the two last cases.

(9.) $x^3 - px + q = 0$.

Let $\sin 3a = \frac{3q}{p} \cdot \frac{1}{2\sqrt{\frac{p}{3}}}$,

Root $x = 2\sqrt{\frac{p}{3}} \cdot \sin a$.

2nd root $x = 2\sqrt{\frac{p}{3}} \cdot \sin (60° - a)$.

3rd root $x = -2\sqrt{\frac{p}{3}} \cdot \sin (60° + a)$.

(10.) $x^3 = xp - q = 0$.

$\text{Sin } 3a = \frac{3q}{p} \cdot \frac{1}{2\sqrt{\frac{p}{3}}}$,

$x = -2\sqrt{\frac{p}{3}} \cdot \sin a$.

$x = -2\sqrt{\frac{p}{3}} \cdot \sin (60° - a)$.

$x = 2\sqrt{\frac{p}{3}} \cdot \sin (60° + a)$.

TABLE XXVII.—Differential Coefficients.

Value of u.	Value of $\frac{du}{dx}$.
(1.) x.	1.
(2.) nx	n.
(3.) x^n.	nx^{n-1}.
(4.) $\log_b x$.	$\frac{m}{x}$ { in which m is the modulus of the system of logarithms.
(5.) $\log_\epsilon x$.	$\frac{1}{x}$ $[\epsilon = 2{\cdot}7182818.]$
(6.) a^x.	$a^x \log_\epsilon a$.
(7.) $\sin x$.	$\cos x$.
(8.) $\cos x$.	$-\sin x$.
(9.) $\tan x$.	$\frac{1}{(\cos x)^2}$.
(10.) $\cot x$.	$-\frac{1}{(\sin x)^2}$
(11.) $(\sin x)^2$.	$2\sin x \cdot \cos x$.
(12.) $(\cos x)^2$.	$-2\sin x \cdot \cos x$.
(13.) $(\tan x)^2$.	$\frac{2\tan x}{(\cos x)^2}$.
(14.) $(\cot x)^2$.	$\frac{2\cot x}{(\sin x)^2}$.
(15.) $\sin^{-1} x$.	$\frac{1}{\sqrt{1-x^2}}$.
(16.) $\cos^{-1} x$.	$-\frac{1}{\sqrt{1-x^2}}$
(17.) $\tan^{-1} x$.	$\frac{1}{1+x^2}$.
(18.) $\varphi x \pm \psi x$.	$\frac{d(\varphi x)}{dx} \pm \frac{d(\psi x)}{dx}$.
(19.) $\frac{\varphi x}{\psi x}$.	$\frac{\psi x \cdot \frac{d(\varphi x)}{dx} - \varphi x \cdot \frac{d(\psi x)}{dx}}{(\psi x)^2}$.
(20.) $fx \cdot \varphi x \cdot \psi x$.	$\varphi x \cdot \psi x \cdot \frac{d(fx)}{dx} + fx \cdot \psi x \cdot \frac{d(\varphi x)}{dx} + fx \cdot \varphi x \cdot \frac{d(\psi x)}{dx}$.
(21.) φv, in which $v = \psi x$.	$\frac{d_v(\psi x)}{dx} \cdot \frac{d_v(\varphi v)}{dv}$

TABLE XXVIII.

Useful Numbers, with their Logarithms.

	Number.	Logarithm.	Complement of Logarithm.
Circumference of a circle whose dia. = 1 . . } $= \pi =$	3·1415927	0·4971499	9·5028501
Area of the same $= \frac{\pi}{4} =$	0·7853982	$\bar{1}$·8950899	10·1049101
Diameter of a circle whose area = 1 } $= \sqrt{\frac{4}{\pi}} =$	1·1283792	0·0524551	9·9475449
Surface of a sphere whose dia. = 1 } $= \pi =$	3·1415927	0·4971499	9·5028501
Solidity of the same . . . $= \frac{\pi}{6} =$	0·5235988	$\bar{1}$·7189986	10·2810014
Diameter of a sphere whose solidity = 1 } $= \sqrt[3]{\frac{6}{\pi}} =$	1·2407010	0·0936672	9·9063328
Length of arc 1″ = sin 1″ (rad. being unity) } $=$	0·000004848	$\bar{6}$·6855749	15·3144251
Length of arc 2″ = sin 2″ (rad. being unity) } $=$	0·000009696	$\bar{6}$·9866049	15·0133951
Length of arc 3″ = sin 3″ (rad. being unity) } $=$	0·000014544	$\bar{5}$·1626961	14·8373039
Length of arc 1′ = sin 1′ (rad. being unity) } $=$	0·000290888	$\bar{4}$·4637261	13·5362739
Length of arc 1° (rad being unity) =	0·017453293	$\bar{2}$·2418774	11·7581226
Length of sin 1° (rad being unity) =	0·017452406	$\bar{2}$·2418553	11·7581447
Radius reduced to seconds . . =	206264·8	5·3144251	4·6855749
„ „ to minutes . . =	3437·74677	3·5362739	6·4637261
„ „ to degrees . . =	57·295780	1·7581226	8·2418774
360 degrees expressed in seconds =	1296000	6·1126050	3·8873940
12 hours expressed in seconds =	43200	4·6354837	5·3645163
24 hours expressed in seconds =	86400	4·9365137	5·0634863
No. whose hyperbolic logarithm is 1 } $= e =$	2·7182818 29	0·4342944	9·5437056
Modulus of common logarithms =	·434294482	$\bar{1}$·6377843	10·3622157
No. of French metres in a toise . =	1·949040	0·2898127	9·7101873
No. of English yards in a French toise } =	2·1315308	0·3286916	9·6713084
No. of English feet in a French toise } =	6·3945925	0·8058128	9·1941872
No. of English yards in a French metre } =	1·0936331	0·0388716	9·8611284
No. of English feet in a French metre } =	3·2808992	0·5159929	9·4840071
No. of English inches in a French metre } =	39·37079	1·5951742	8·4048258
No. of English feet in a French foot =	1·0657654	0·0276616	9·9723384
No. of English acres in a French are =	0·02471143	$\bar{2}$·3928978	11·6071022
No. of imp. lbs. Troy in a French gramme } =	0·00268098	$\bar{3}$·4282936	12·5717064

TABLE XXVIII.

Useful Numbers, with their Logarithms.

	Number.	Logarithm.	Complement of Logarithm.
No. of imp. lbs. Avoird. in a French gramme =	0·00220606	$\bar{3}$·3436173	12·6563827
No. of English cwts. in a French kilogramme =	0·0196969	$\bar{2}$·2943979	11·7056021
No. of imp. gallons in a French litre =	0·22009687	$\bar{1}$·3426137	10·6573863
No. of Sexagesimal degrees in a Centesimal degree =	0·9	$\bar{1}$·9542425	10·0457575
No. of Sexagesimal minutes in a Centesimal minute . . . =	0·54	$\bar{1}$·7323938	10·2676062
No. of Sexagesimal seconds in a Centesimal second . . . =	0·324	$\bar{1}$·5105450	10·4894540
Weight of a cubic foot of pure water in lbs. Avoird. the Bar. being 30, and the Ther. 62° =	62·3210606	1·7946348	8·2053652
Length in inches of a pendulum which vibrates seconds in the latitude of Greenwich . . =	39·1393	1·5926130	8·4073860
Velocity (in feet per second) acquired in a second by a body falling in vacuo in the lat. of Greenwich . = g =	32·19084	1·5077222	8·4922778
No. of cubic inches in an imperial gallon =	277·274	2·4429092	7·5570908
No. of feet in a statute mile . =	5280	3·7226339	6·2773661
No. of feet in a geographical or nautical mile =	6075·6	3·7835892	6·2164108
Diurnal acceleration of stars (= $3^m\ 55^s{\cdot}9093$) expressed in mean solar seconds . . . =	235·9093	2·3727441	8·6272559
Sidereal day (= $23^h\ 56^m\ 4^s{\cdot}09$) expressed in mean solar days =	0·99726967	$\bar{1}$·9988127	10·0011873
Mean solar day (= $24^h\ 3^m\ 56^s{\cdot}5554$) expressed in sidereal days . =	1·00273791	0·0011874	9·9988126
Sidereal revolution of Earth expressed in mean solar days . =	365·25636	2·5625978	7·4374022
Tropical revolution of Earth expressed in mean solar days . =	365·24224	2·5625910	7·4374080
Earth's equatorial radius expressed in feet =	20921665	7·3205963	2·6794037
Earth's polar radius expressed in feet =	20852394	7·3191559	2·6808441
Compression of the Earth . . =	$\frac{1}{302}$	$\bar{3}$·5199931	12·4800069
Length of a degree of latitude in feet at the Equator . . . =	362732	5·5595859	4·4404141
Length of a degree of latitude in feet in latitude 45° . . . =	364543·5	5·5617494	4·4382506

TABLE XXIX.

SUN'S DECLINATION.

Long.	0°	2°	4°	6°	8°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	23° 15′	Time from Noon.
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	h m
0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
1	0 4	0 4	0 4	0 4	0 4	0 4	0 4	0 3	0 3	0 3	0 3	0 3	0 3	0 3	0 2	0 2	0 2	0 1	0 1	0 1	0 4
2	0 8	0 8	0 8	0 8	0 8	0 7	0 7	0 7	0 7	0 6	0 6	0 6	0 6	0 5	0 5	0 5	0 4	0 3	0 2	0 1	0 8
3	0 12	0 12	0 12	0 11	0 11	0 11	0 11	0 10	0 10	0 9	0 9	0 9	0 8	0 8	0 7	0 6	0 5	0 4	0 2	0 2	0 12
4	0 16	0 16	0 16	0 15	0 15	0 14	0 14	0 14	0 13	0 12	0 12	0 12	0 11	0 10	0 10	0 8	0 8	0 6	0 3	0 2	0 16
5	0 20	0 20	0 20	0 19	0 19	0 18	0 18	0 17	0 16	0 15	0 15	0 15	0 14	0 13	0 12	0 11	0 9	0 7	0 4	0 3	0 20
6	0 24	0 24	0 24	0 23	0 23	0 22	0 21	0 20	0 20	0 18	0 18	0 18	0 16	0 16	0 14	0 13	0 10	0 8	0 4	0 4	0 24
7	0 27	0 27	0 27	0 26	0 26	0 25	0 25	0 24	0 23	0 22	0 21	0 21	0 19	0 19	0 17	0 15	0 13	0 10	0 6	0 4	0 28
8	0 31	0 31	0 31	0 30	0 30	0 29	0 29	0 27	0 27	0 26	0 24	0 24	0 22	0 21	0 19	0 17	0 15	0 11	0 7	0 4	0 32
9	0 35	0 35	0 35	0 34	0 34	0 32	0 32	0 31	0 30	0 28	0 27	0 27	0 24	0 24	0 21	0 19	0 16	0 12	0 7	0 5	0 36
10	0 39	0 39	0 39	0 38	0 37	0 36	0 35	0 34	0 33	0 32	0 31	0 29	0 28	0 26	0 24	0 21	0 18	0 14	0 8	0 6	0 40
20	1 19	1 18	1 17	1 16	1 14	1 12	1 10	1 8	1 6	1 4	1 2	0 59	0 56	0 52	0 48	0 43	0 37	0 29	0 16	0 11	1 20
30	1 58	1 57	1 56	1 54	1 51	1 48	1 45	1 43	1 39	1 36	1 32	1 28	1 23	1 18	1 11	1 4	0 55	0 43	0 25	0 17	2 0
40	2 37	2 36	2 35	2 32	2 28	2 24	2 20	2 17	2 13	2 8	2 2	1 57	1 51	1 44	1 35	1 25	1 13	0 58	0 33	0 22	2 40
50	3 16	3 15	3 13	3 10	3 6	3 0	2 56	2 51	2 46	2 41	2 34	2 27	2 19	2 10	1 59	1 47	1 31	1 12	0 41	0 28	3 20
60	3 55	3 54	3 52	3 48	3 43	3 35	3 31	3 25	3 19	3 13	3 5	2 56	2 47	2 36	2 23	2 8	1 49	1 26	0 49	0 34	4 0
70	4 35	4 33	4 31	4 26	4 20	4 12	4 6	3 59	3 53	3 45	3 36	3 25	3 15	3 2	2 47	2 29	2 8	1 41	0 58	0 39	4 40
80	5 14	5 12	5 10	5 4	4 57	4 48	4 41	4 34	4 26	4 17	4 7	3 55	3 43	3 28	3 11	2 51	2 26	1 55	1 6	0 44	5 20
90	5 53	5 52	5 48	5 42	5 34	5 23	5 16	5 8	4 59	4 49	4 37	4 25	4 10	3 54	3 34	3 12	2 44	2 2	1 14	0 50	6 0
100	6 32	6 31	6 27	6 21	6 11	5 59	5 51	5 42	5 32	5 21	5 9	4 53	4 38	4 20	3 58	3 33	3 3	2 24	1 22	0 56	6 40
110	7 11	7 10	7 6	6 59	6 48	6 35	6 26	6 16	6 5	5 53	5 40	5 23	5 6	4 46	4 23	3 55	3 21	2 38	1 30	1 1	7 20
120	7 51	7 49	7 44	7 37	7 25	7 11	7 1	6 51	6 39	6 25	6 10	5 53	5 34	5 12	4 46	4 16	3 39	2 53	1 39	1 7	8 0
130	8 30	8 27	8 23	8 15	8 2	7 47	7 36	7 25	7 12	6 57	6 41	6 21	6 2	5 38	5 11	4 37	3 58	3 3	1 47	1 12	8 40
140	9 9	9 7	9 2	8 53	8 40	8 23	8 12	7 59	7 45	7 30	7 12	6 51	6 30	6 4	5 34	4 59	4 16	3 21	1 55	1 18	9 20
150	9 48	9 45	9 40	9 30	9 17	8 58	8 47	8 33	8 18	8 2	7 42	7 21	6 57	6 30	5 57	5 20	4 33	3 35	2 4	1 24	10 0
160	10 28	10 25	10 20	10 9	9 54	9 35	9 22	9 8	8 52	8 34	8 13	7 49	7 25	6 56	6 21	5 41	4 52	3 50	2 12	1 29	10 40
170	11 6	11 4	10 58	10 47	10 31	10 11	9 57	9 42	9 25	9 6	8 45	8 19	7 53	7 22	6 46	6 5	5 11	4 5	2 22	1 34	11 20
180	11 46	11 43	11 37	11 25	11 8	10 46	10 32	10 16	9 58	9 38	9 15	8 49	8 21	7 48	7 9	6 24	5 29	4 19	2 28	1 40	12 0

CHAP. II.

PLANE AND SOLID GEOMETRY.

SECT. I.—*Definitions.*

1. GEOMETRY is that department of science, by means of which we demonstrate the properties, affections, and measures of all sorts of *magnitude.*

2. *Magnitude* is a term used to denote the extension of any thing, and is of three kinds; as the magnitude of a *line,* which is only in *one* direction, viz., *length;* the magnitude of a *surface,* which is in *two* directions, viz., *length* and *breadth;* and the magnitude of a *solid,* which is in *three* directions, viz., *length, breadth* and *depth.*

3. A *point* has no parts or magnitude; neither length, breadth, nor thickness, and serves only to assign *position.*

4. A *line* has length without breadth or thickness, and indicates direction and distance.

Cor. The extremities of a line are, therefore, points.

5. A *right line* is that which lies evenly, or in the same direction, between two points. A *curve line* continually changes its direction.

Cor. Hence there can only be one species of right lines, but there is an infinite variety in the species of curves.

6. An *angle* is the inclination of two lines to one another, meeting in a point, called the *angular point.* When it is formed by two *right lines,* it is a *plane* angle, as A; if by *curve* lines, it is a *curvilineal* angle, as B. (Fig. 1.)

7. A *right angle* is that which is made by one right line A B falling upon another C D, and making the angles on each side equal, that is, A B C = A B D: so that the line A B does not incline more to one side than another: it is then said to be *perpendicular* to the line C D. All other angles are called *oblique* angles. (Fig. 2.)

8. An *obtuse angle* is *greater* than a right angle, as R. (Fig. 3.)

9. An *acute angle* is *less* than a right angle, as S. (Fig. 3.)

10. *Contiguous* or *adjacent angles,* are the two angles formed by one line falling upon another, as R, S. (Fig. 3.)

11. *Vertical* or *opposite* angles, are those made on contrary sides of two lines intersecting one another, as A E C, D E B. (Fig. 4.)

12. A *surface* has length and breadth, but no thickness, and shews extension. The area of a figure is the quantity of space which its surface occupies.

Cor. The boundaries or limits of a surface are lines.

13. A *plane* is that surface which lies perfectly even between its extremes; or which, being cut by another plane in any direction, its section would be a straight line.

14. A *solid* is a magnitude extended every way, or which has length, breadth, and depth.

Cor. The boundaries or extremes of a solid are surfaces.

15. The *square* of a right line is the space included by four right lines equal to it, set perpendicular to one another.

16. The *rectangle* of two lines is the space included by four lines equal to them, set perpendicular to one another, the opposite ones being equal.

17. One right line is said to be *parallel* to another, when both lines, being extended to any length, will never meet, but always preserve the same distance between them.

SECT. II.—*Of Angles, and Right Lines, and their Rectangles.*

PROP. I. If to any point C in a right line A B, several other right lines D C, E C are drawn on the same side; all the angles formed at the point C, taken together, are equal to two right angles; thus, A C D + D C E + E C B = the two right angles A C P + P C B. (Fig. 5.) [Euclid, Book I. Prop. 13.]

Cor. 1. All the angles made about one point in a plane, being taken together, are equal to four right angles.

Cor. 2. If all the angles at C, on one side of the line A B, are found to be equal to two right angles; then A C B is a straight line. (Fig. 5.) [Euc. B. I. Prop. 14.]

II. If two right lines, A B, C D, cut one another, the opposite angles C E B and A E D will be equal. (Fig. 4.) [Euc. B. I. Prop. 15.]

III. A right line, B I, which is perpendicular to one of two parallels, is perpendicular to the other. (Fig. 6.)

IV. If a right line C G, intersects two parallels A D, F H; the alternate angles, A B E, and B E H, will be equal. (Fig. 6.) [Euc. B. I. Prop. 29.]

Cor. 1. The two internal angles D B E and B E H on the same side are equal to two right angles. (Fig. 6.)

Cor. 2. The external angle C B D, is equal to the internal angle on the same side B E H. (Fig. 6.) [Euc. B. I. Prop. 28.]

V. Right lines, parallel to the same right line, are parallel to one another. [Euc. B. I. Prop. 30.]

VI. If a right line A C be divided into two parts A B, B C; the square of the whole line is equal to the squares of both the parts, and twice the rectangle of the parts; or $A C^2 = A B^2 + B C^2 + 2 A B \times B C$. (Fig. 7.) [Euc. B. II. Prop. 4.]

VII. The square of the difference of two lines A C, B C, is equal to the sum of their squares, wanting twice their rectangle; or $A B^2 = A C^2 + B C^2 - 2 A C \times B C$. Or $A B^2 + 2 A C \times B C = A C^2 + B C^2$ (Fig. 7.) [Euc. B. II. Prop. 7.]

VIII. The square of the sum of two lines is equal to the sum of their squares, together with their rectangle.

IX. The rectangle of the sum and difference of two lines is equal to the difference of their squares.

X. The square of the sum, together with the square of the difference of two lines, is equal to twice the sum of their squares.

SECT. III.—*Of Triangles.*

DEFINITIONS.

1. A *triangle* is a plane figure bounded by three right lines, called the *sides* of the triangle.

2. An *equilateral triangle* is one in which all the three sides are equal.

3. An *isosceles triangle* has only two sides equal.

4. A *scalene triangle* has all its three sides unequal.

5. An *equiangular triangle* is one which has three equal angles; and *two* triangles are said to be *equiangular*, when the angles in the one are respectively equal to those in the other.

6. A *right-angled triangle* is that which has one of its angles a right angle. The side opposite to the right angle is called the *hypothenuse*, and the other two sides the *legs*.

7. An *oblique angled triangle* has all its angles oblique.

8. An *obtuse angled triangle* has one of its angles obtuse.

9. An *acute angled triangle* has all its angles acute.

10. In a triangle, the lowest side, as A B, is called the *base*, and the opposite angle C the *vertex*: the *altitude* of a triangle is the perpendicular height (C D) from the base, or its extension to the vertex. (Fig. 8.)

11. *Similar triangles* are those whose angles or sides are respectively equal, each to each. And *homologous sides* are those lying between equal angles.

PROPOSITIONS.

PROP. I. In any triangle A B C, if one side B C be produced or drawn out; the external angle A C D will be equal to the two internal opposite angles A B C and B A C. (Fig. 9.) [Euc. B. I. Prop. 32.]

II. In any triangle, the sum of the three internal angles is equal to two right angles. [Euc. B. I. Prop. 32.]

Cor. 1. If two angles in one triangle be equal to two angles in another: the third will also be equal to the third.

Cor. 2. If one angle of a triangle be a right angle, the sum of the other two will be equal to a right angle.

III. The angles at the base of an isosceles triangle, are equal. [Euc. B. I. Prop. 5.]

Cor. 1. An equilateral triangle is also equiangular; and the contrary.

Cor. 2. The line which is perpendicular to the base of an isosceles triangle, bisects both it and the vertical angle.

IV. In any triangle, the greatest side is opposite to the greatest angle, and the least to the least. [Euc. B. I. Prop. 18.]

V. In any triangle A B C, the sum of any two sides B A, A C, is greater than the third B C, and their difference is less than the third side. (Fig. 10.) [Euc. B. I. Prop. 20.]

VI. If two triangles A B C, *a b c*, have two sides, and the included angle equal in each; these triangles, and their correspondent parts, shall be equal. (Fig. 11.) [Euc. B. I. Prop. 4.]

VII. If two triangles A B C and *a b c*, have two angles and an included side equal, each to each; the remaining parts shall be equal, and the whole triangles equal. (Fig. 11.) [Euc. B. I. Prop. 26.]

VIII. Triangles of equal bases and heights are equal. [Euc. B. I. Prop. 37.]

IX. Triangles of the same height, are in proportion to one another as their bases. [Euc. B. VI. Prop. 1.]

X. If a line D E be drawn parallel to one side B C, of a triangle; the segments of the other sides will be proportional; that is, A D : D B : : A E : E C. (Fig. 12.) [Euc. B. VI. Prop. 2.]

Cor. 1. If the segments be proportional, A D : D B : : A E : E C; then the line D E is parallel to the side B C. (Fig. 12.)

Cor. 2. If several lines be drawn parallel to one side of a triangle, all the segments will be proportional.

Cor. 3. A line drawn parallel to any side of a triangle, cuts off a triangle similar to the whole.

XI. In similar triangles, the homologous sides are proportional; that is, A B : A C : : D E : D F. (Fig. 13.) [Euc. B. VI. Prop. 4.]

XII. Like triangles are in the duplicate ratio, or as the squares of, their homologous sides. [Euc. B. VI. Prop. 19.]

XIII. In any triangle, the difference of the squares of the two legs A B and A C, is equal to twice the rectangle contained by the base B C, and the distance D O, of its middle point from the perpendicular D A. (Fig. 14.)

XIV. In a right-angled triangle B A C, if a perpendicular be let fall from the right angle upon the hypothenuse, it will divide it into two triangles, similar to one another and to the whole, A B D, A D C. (Fig. 14.) [Euc. B. VI. Prop. 8.]

Cor. 1. The rectangle of the hypothenuse and either segment is equal to the square of the adjoining side.

XV. The distance A O of the right angle, from the middle of the hypothenuse is equal to half the hypothenuse. (Fig. 14.)

XVI. In a right-angled triangle, the square of the hypothenuse is equal to the sum of the squares of the two sides. [Euc. B. I. Prop. 47.]

XVII. If the square of one side of a triangle be equal to the sum of the squares of the other two sides; then the angle comprehended by them is a right angle. [Euc. B. I. Prop. 48.]

XVIII. If an angle A, of a triangle B A C be bisected by a right line A D, which cuts the base; the segments of the base will be proportional to the adjoining sides of the triangle; that is, B D : D C : : A B : A C. (Fig. 10.) [Euc. B. VI. Prop. 3.]

XIX. If the sides be as the segments of the base, the line A D bisects the angle A. (Fig. 10.) [Euc. B. VI. Prop. A.]

XX. Three lines drawn from the three angles of a triangle to the middle of the opposite sides, all meet in one point.

XXI. Three perpendicular lines erected on the middle of the three sides of any triangle, all meet in one point.

XXII. The point of intersection of the three perpendiculars, will be equally distant from the three angles; or, it will be the centre of the circumscribing circle.

XXIII. Three perpendiculars drawn from the three angles of a triangle, upon the opposite sides, all meet in one point.

XXIV. Three lines bisecting the three angles of a triangle, all meet in one point.

XXV. If D be any point in the base of a scalene triangle, A B C: then is $A B^2 \times D C + A C^2 \times B D = A D^2 \times B C + B C \times B D \times D C$. (Fig. 10.)

SECT. IV.—*Of Quadrilaterals and Polygons.*

DEFINITIONS.

1. A *quadrangle* or *quadrilateral*, is a plane figure bounded by four right lines.

2. A *parallelogram* is a quadrangle whose opposite sides are parallel, as A G B H. The line A B drawn to the opposite corners is called the *diameter* or *diagonal*. And if two lines be drawn parallel to the two sides, through any point of the diagonal, they divide it into several others, and then C and D are called parallelograms about the diameter; and E and F the *complements;* and the figure E D F a *gnomon*. (Fig. 15.)

3. A *rectangle* is a parallelogram whose sides are perpendicular to one another.

4. A *square* is a rectangle of four equal sides and four equal angles.

5. A *rhombus* is a parallelogram, whose sides are equal, and all its angles oblique.

6. A *rhomboid* is a parallelogram in which only the opposite sides are equal, and all its angles oblique.

7. A *trapezoid* is a quadrangle, having only two sides parallel, as Fig. 16.

8. A *trapezium* is a quadrangle that has no two sides parallel, as Fig. 17.

9. A *polygon* is a plane figure enclosed by many right lines. If all the sides and angles are equal, it is called a *regular* polygon, and denominated according to the number of sides or angles, as a *pentagon* having five sides, a *hexagon*, having six sides, a *heptagon*, having seven sides, &c.

10. The *diagonal* of a quadrangle or polygon is a line drawn between any two opposite corners of the figure, as A B. (Fig. 15.)

11. The *height* of a figure is a line drawn from its *vertex*, perpendicular to the base, or opposite side on which it stands.

12. *Like* or *similar* figures, are those whose several angles are equal to one another, and the sides about the equal angles proportional.

13. *Homologous* sides of two like figures are those between two angles, respectively equal.

14. The *perimeter* or circumference of a figure, is the compass of it, or sum of all the lines that enclose it.

15. The *internal angles* of a figure are those on the inside, made by the lines that bound the figure, as A B C, D C B, &c. (Fig. 18.)

16. The *external angles* of a figure are the angles made by each side of a figure, and the adjoining side drawn out, as B A F, A E G. (Fig. 18.)

PROPOSITIONS.

PROP. I. In any parallelogram the opposite sides and angles are equal; and the diagonal divides it into two equal triangles. [Euc. B. I. Prop. 34.]

II. The diagonals of a parallelogram intersect each other in the middle point of both.

III. Any line B C passing through the middle of the diagonal of a parallelogram P, divides the area into two equal parts. (Fig 19.)

IV. Any right line B C drawn through the middle point P of the diagonal of a parallelogram, is bisected in that point; or B P = P C. (Fig. 19.)

V. In any parallelogram A G H B, the complements E and F are equal. (Fig. 15.) [Euc. B. I. Prop. 43.]

VI. Parallelograms of equal bases and heights are equal. [Euc. B. I. Prop. 36.]

VII. The area of a parallelogram is double the area of a triangle having the same base and height. [Euc. B. I. Prop. 41.]

VIII. Parallelograms of the same height are to one another as their bases. [Euc. B. VI. Prop. 1.]

IX. Parallelograms of equal bases are as their heights.

X. Parallelograms are to one another, as their bases and heights.

XI. In any parallelogram the sum of the squares of the diagonals is equal to the sum of the squares of all the four sides.

XII. The sum of the four internal angles of any quadrilateral figure, is equal to four right angles.

XIII. If two angles of a quadrangle be right angles, the sum of the other two amounts to two right angles.

XIV. The sum of all the internal angles of a polygon is equal to twice as many right angles, abating four, as the polygon has sides.

Cor. Hence all right-lined figures of the same number of sides, have the sum of all the internal angles equal.

XV. The sum of the external angles of any polygon is equal to four right angles.

Cor. All right-lined figures have the sum of their external angles equal.

XVI. In two similar figures A C, P R; if two lines B E, Q T, be drawn after a like manner, as suppose, to make the angle C B E = R Q T; then these lines have the same proportion as any two homologous sides of the figure; viz.,

B E : Q T :: B C : Q R :: A B : P Q :: A D : P S. (Fig. 20.)

XVII. All similar figures are to one another as the squares of their homologous sides.

XVIII. Any figure described on the hypothenuse of a right-angled triangle, is equal to two similar figures described the same way upon the two legs; that is, B F C = A L C + A G B. (Fig. 21.) [Euc. B. VI. Prop. 31.]

XIX. Any regular figure A B C D E, is equal to a triangle whose base is the perimeter A B C D E A; and height the line O P, drawn from the centre, perpendicular to one side. (Fig. 22.)

XX. Only three sorts of regular figures can fill up a plane surface, that is, the whole space round an assumed point, and these are six triangles, four squares, or three hexagons.

SECT. V. *Of the Circle, and Inscribed and Circumscribed Figures.*

DEFINITIONS.

1. A *circle* is a plane figure described by a right line moving about a fixed point, as A C about C: or it is a figure bounded by a curved line, every part of which is equidistant from a fixed point. (Fig. 23.)

2. The *centre* of a circle is the fixed point about which the line moves, as C. (Fig. 23.)

3. The *radius* is the line that describes the circle, as C A. (Fig. 23.)

Cor. All the radii of a circle are equal.

4. The *circumference* is the line described by the extreme end of the moving line, as A B D E A. (Fig. 23.)

5. The *diameter* is a line drawn through the centre, from one side to the other, as A D. (Fig. 23.)

6. A *semicircle* is half the circle, cut off by the diameter, as A B D.

7. A *quadrant*, or quarter of a circle, is the part between two radii perpendicular to one another, as C D E. (Fig. 23.)

8. An *arc* is any part of the circumference, as A B. (Fig. 24.)

9. A *sector* is a part bounded by two radii, and the arc between them, as A C B. (Fig. 24.)

10. A *chord* is a right line drawn through the circle, as D F.

11. A *segment* is a part cut off by a right line, or chord, as D E F, or D A B F. (Fig. 24.)

12. *Angle at the centre* is that whose angular point is at the centre A C B. (Fig. 24.)

13. *Angle at the circumference* is when the angular point is in the circumference, as B A D, or B C D. (Fig. 25.)

14. *Angle in a segment*, is the angle made by two lines drawn from some point of the arc of that segment to the ends of the base; as B C D is an angle in the segment B C D. (Fig. 25.)

15. *Angle upon a segment* is the angle made in the opposite segment, whose sides stand upon the base of the first; as B A D, which stands upon the segment B C D. (Fig. 25.)

16. A *tangent* is a line touching a circle, which, produced, does not cut it, as G A F. (Fig. 23.)

17. Circles are said to touch one another, which meet, but do not cut one another.

18. *Similar arcs*, or *similar sectors*, are those bounded by radii that make the same angle.

19. *Similar segments* are those which contain similar triangles, alike placed.

20. A figure is said to be *inscribed in a circle*, or a circle *circumscribed about a figure*, when all the angular points of the figure are in the circumference of the circle. (Fig. 26.)

21. A circle is said to be *inscribed in a figure*, or a figure *circumscribed about a circle*, when the circle touches all the sides of the figure. (Fig. 27.)

22. *One figure is inscribed in another*, when all the angles of the inscribed figure are in the sides of the other. (Fig. 28.)

PROPOSITIONS.

PROP. I. The radius C R, bisects any chord at right angles, which does not pass through the centre, as A B. (Fig. 29.) [Euc. B. III. Prop. 3.]

Cor. 1. If a line bisects a chord at right angles, it passes through the centre of the circle.

Cor. 2. The radius that bisects the chord also bisects the arc.

II. In a circle equal chords are equally distant from the centre. [Euc. B. III. Prop. 14.]

III. If several lines be drawn through a circle, the greatest is the diameter, and those that are nearest the centre are greater than those that are farther off. [Euc. B. III. Prop. 15.]

IV. If from any point three equal right lines can be drawn to the circumference, that point is the centre. [Euc. B. III. Prop. 9.]

V. No circle can cut another in more than two points. [Euc. B. III. Prop. 10.]

VI. There can be only two equal lines drawn from any exterior point, to the circumference of a circle.

VII. In any circle, if several radii be drawn making equal angles, the arcs and sectors comprehended thereby will be equal; that is, if the angle A C B = B C D, then, the arc A B = B D, and the sector A C B = B C D. (Fig. 30.) [Euc. B. III. Prop. 26.]

VIII. In the same or equal circles, the arcs, and also the sectors, are proportional to the angles intercepted by the radii.

IX. The circumferences of circles are to one another as their diameters.

X. A right line, perpendicular to the diameter of a circle, at the extreme point, touches the circle in that point, and lies wholly without the circle; or is a tangent to the circle.

XI. If two circles touch one another, either inwardly or outwardly, the line passing through their centres shall also pass through the point of contact. [Euc. B. III. Prop. 11 and 12.]

XII. In a circle the angle at the centre is double the angle at the circumference, standing upon the same arc; or B D C = 2 B A C. (Fig. 31.) [Euc. B. III. Prop. 20.]

XIII. All angles in the same segment of a circle are equal, as D A C = D B C, and D G C = D H C. (Fig. 32.) [Euc. B. III. Prop. 21.]

XIV. If two right lines D C, A B, be drawn from the extremities of two equal arcs D A, B C, they will be parallel. (Fig. 32.)

XV. The angle A B C in a semicircle is a right angle. (Fig. 33.) [Euc. B. III. Prop. 31.]

XVI. The angle F B G, in a greater segment F A B C G, is less than a right angle; and the angle D B E, in a less segment D B E, is greater than a right angle. (Fig. 33.) [Euc. B. III. Prop. 31.]

XVII. If two lines cutting a circle, intersect one another in A; and there be made at the centre, $\angle$ E C F = $\angle$ B A D; then the arc B D + G H = 2 E F, if A is within the circle; or the arc B D − G H = 2 E F, if A is without. (Fig. 34.)

XVIII. If from a point without, two lines, A B, A D be drawn to cut a circle; the angle made by them is equal to the angle at the centre, standing on half the difference of the two arcs of the circumference G H, B D. (Fig. 34.)

XIX. The angle A = $\angle$ B H D + H D G, when A is within; or A = B H D − H D G, when A is without the circle. (Fig. 34.)

XX. In a circle, the angle made at the point of contact between the tangent and any chord, is equal to the angle in the alternate or opposite segment; E C F = E B C, and E C A = E G C. (Fig. 35.) [Euc. B. III. Prop. 32.]

XXI. A tangent to the middle point of an arc, is parallel to the chord of it.

XXII. If from any point B in a semicircle, a perpendicular B D be let fall upon the diameter, it will be a mean proportional between the segments of the diameter; that is, A D : D B :: D B : D C. (Fig 36.) [Euc. B. VI. Prop. 13.]

XXIII. The chord is a mean proportional between the adjoining segment and the diameter, from the similarity of the triangles: that is, A D : A B :: A B : A C; and C D : C B :: C B : C A. (Fig. 36.)

XXIV. In a circle, if the diameter A D be drawn, and from the ends of the chords A B, A C, perpendiculars be drawn upon the diameter; the squares of the chords will be as the segments of the diameter; that is, A E : A F :: $A B^2$: $A C^2$. (Fig. 37.)

XXV. If two circles touch one another in P, and the line P D E be drawn through their centres; and any line P A B is drawn through that

point to cut the circles, that line will be divided in proportion to the diameters; that is, P A : P B :: P D : P E. (Fig. 38.)

XXVI. If through any point F in the diameter of a circle, any chord, C F D be drawn, the rectangle of the segments of the chord is equal to the rectangle of the segments of the diameter; C F × F D = A F × F B = also G F × F E. (Fig. 39.) [Euc. B. III. Prop. 35.]

XXVII. If through any point F out of the circle in the diameter B A produced, any line F C D be drawn through the circle: the rectangle of the whole line and the external part is equal to the rectangle of the whole line passing through the centre, and the external part; D F × F C = A F × F B = also F E × F G. (Fig. 40.)

XXVIII. Let H F be a tangent at H; then the rectangle C F × F D = square of the tangent F H. (Fig. 40.) [Euc. B. III. Prop. 36.]

XXIX. If from the same point F, two tangents be drawn to the circle, they will be equal; that is, F H = F I. (Fig. 40.)

XXX. If a line P F C be drawn perpendicular to the diameter A D of a circle; and any line drawn from A to cut the circle and the perpendicular; then the rectangle of the distances of the sections from A, will be equal to the rectangle of the diameter and the distance of the perpendicular from A; that is, A B × A C = A P × A D. (Fig. 41.)

Also, A B × A C = A K^2. (Fig. 41.)

XXXI. In a circle E D F whose centre is C, and radius C E, if the points B, A, be so placed in the diameter produced, that C B, C E, C A be in continual proportion, then two lines B D, A D drawn from these points to any point in the circumference of the circle will always be in the given ratio of B E to A E. (Fig. 42.)

XXXII. In a circle, if a perpendicular D B be let fall from any point D, upon the diameter C I, and the tangent D O drawn from D, then A B, A C, A O, will be in continual proportion. (Fig. 43.)

XXXIII. If a triangle B D F be inscribed in a circle, and a perpendicular D P let fall from D on the opposite side B F, and the diameter D A drawn; then, as the perpendicular is to one side including the angle D, so is the other side to the diameter of the circle; that is, D P : D B :: D F : D A. (Fig. 44.)

XXXIV. The rectangle of any two sides of an inscribed triangle is equal to the rectangle of the diameter, and the perpendicular on the third side; that is, B D × D F = A D × D P. (Fig. 44.)

XXXV. If a triangle B A C be inscribed in a circle, and the angle A bisected by the right line A E D, then as one side is to the segment of the bisecting line within the triangle, so is the whole bisecting line to the other side; that is, A B : A E :: A D : A C; and A B × A C = B E . E C + A E^2. (Fig. 45.)

XXXVI. If a quadrilateral A B C D be inscribed in a circle, the sum of two opposite angles is equal to two right angles; that is, A D C + A B C = two right angles. (Fig. 46.) [Euc. B. III. Prop. 22.]

XXXVII. If a quadrangle be inscribed in a circle, the rectangle of the diagonals is equal to the sum of the rectangles of the opposite sides; or $C A \times B D = C B \times D A + C D \times A B$. (Fig. 46.)

XXXVIII. A circle is equal to a triangle whose base is the circumference of the circle; and height, its radius.

XXXIX. The area of a circle is equal to the rectangle of half the circumference and half the diameter.

XL. Circles (that is, their areas) are to one another as the squares of their diameters, or as the squares of the radii, or as the squares of the circumferences. [Euc. B. XII. Prop. 2.]

XLI. Similar polygons inscribed in circles, are to one another as the circles wherein they are inscribed.

XLII. A circle is to any circumscribed rectilineal figure, as the circle's periphery to the periphery of the figure.

XLIII. If an equilateral triangle A B C be inscribed in a circle; the square of the side thereof is equal to three times the square of the radius; that is, $A B^2 = 3 A D^2$. (Fig. 47.)

XLIV. If from any point D in the circumference of a circle, having inscribed in it an equilateral triangle, chords be drawn to the three angles A, B, C; the longest chord A D, is equal to the sum of the two lesser chords, B D and C D. (Fig. 48.)

XLV. A square inscribed in a circle, is equal to twice the square of the radius.

XLVI. The side of a regular hexagon inscribed in a circle, is equal to the radius of the circle.

XLVII. If two chords in a circle mutually intersect at right angles, the sum of the squares of the segments of the chords is equal to the square of the diameter of the circle; that is, $A P^2 + P B^2 + P C^2 + P D^2 = \text{diam.}^2$ (Fig. 49.)

XLVIII. If the diameter P Q be divided into two parts at any point R, and if R S be drawn perpendicular to P Q; also R T applied equal to the radius, and T R produced to the circumference at V: then,

$R T = \frac{P R + R Q}{2}$; or R T is the *arithmetical* mean,

$R S = \sqrt{P R \times R Q}$; or R S is the *geometrical* mean,

$R V = \frac{2 \times P R \times R Q}{P R + R Q}$; or R V is the *harmonical* mean,

} between the two segments of the diameter P R, Q R (Fig. 50.)

XLIX. If the arcs P Q, Q R, R S, &c., be equal, and there be drawn the chords P Q, P R, P S, &c., then it will be $P Q : P R :: P R : P Q + P S :: P S : P R + P T :: P T : P S + P V$, &c. (Fig. 51.)

L. If the arcs P Q, Q R, R S, &c., be equal, the angles Q P R, R P S, S P T, &c., will be equal; or in equal circles, equal angles stand upon equal arcs, whether they be at the centres or circumferences. (Fig. 51.) [Euc. B. III. Prop. 26.]

LI. The centre of a circle being O, and P a point in the radius, or in the radius produced; if the circumference be divided into as many equal

parts A B, B C, C D, &c., as there are units in $2n$, and lines be drawn from P to all the points of division; then shall the continual product of all the alternate lines, viz., P A × P C × P E, &c., be $= r^n - x^n$ when P is within the circle, or $= x - r^n$ when P is without the circle; and the product of the rest of the lines, viz., P B × P D × P F, &c., $= r^n + x^n$: where $r =$ A O the radius, and $x =$ O P the distance of P from the centre. (Fig. 52.)

Sect. VI.—*Of Planes and Solids.*

DEFINITIONS.

1. The *common section* of two planes, is the line in which they meet, or cut each other.

2. A line is *perpendicular* to a plane, when it is perpendicular to every line in that plane which meets it.

3. One plane is *perpendicular* to another, when every line of the one, which is perpendicular to the line of their common section, is perpendicular to the other.

4. The *inclination* of one plane to another, or the angle they form between them, is the angle contained by two lines, drawn from any point in the common section, and at right angles to the same, one of these lines in each plane.

5. *Parallel Planes* are such as being produced ever so far in any direction, will never meet, or which are everywhere at an equal perpendicular distance.

6. A *solid angle* is that which is made by three or more plane angles, meeting each other in the same point.

7. *Similar solids*, contained by plane figures, are such as have all their solid angles equal, each to each, and are bounded by the same number of similar planes, alike placed.

8. A *prism* is a solid whose ends are parallel, equal, and like plane figures, and its sides, connecting those ends, are parallelograms. (Fig. 53 and 54.)

9. A prism takes particular names according to the figure of its base or ends, whether triangular, square, rectangular, pentagonal, hexagonal, &c.

10. A *right* or *upright prism*, is that which has the planes of the sides perpendicular to the planes of the ends or base. (Fig. 53.) When such is not the case it is called an *oblique* prism. (Fig. 54.)

11. A *parallelopiped*, or *parallelopipedon*, is a prism bounded by six parallelograms, every opposite two of which are equal, alike, and parallel. (Fig 55.)

12. A *rectangular parallelopipedon* is that whose bounding planes are all rectangles, which are perpendicular to each other. (Fig. 56.)

13. A *cube* is a square prism, being bounded by six equal square sides or faces, which are perpendicular to each other. (Fig. 57.)

14. A *cylinder* is a round prism having circles for its ends; and is conceived to be formed by the rotation of a right line about the circumferences of two equal and parallel circles, always parallel to the axis. (Fig. 58.)

15. The *axis* of a cylinder is the right line A B joining the centres of the two parallel circles, about which the figure is described.

16. A *pyramid* is a solid whose base is any right-lined plane figure, and its sides triangles, having all their vertices meeting together in a point above the base, called the *vertex* of the pyramid. (Fig. 59.)

17. Pyramids, like prisms, take particular names from the figure of their base.

18. A *cone* is a round pyramid having a circular base, and is conceived to be generated by the rotation of a right line about the circumference of a circle, one end of which is fixed at a point above the plane of that circle. (Fig. 60.)

19. The *axis* of a cone is the right line, A B, joining the vertex, or fixed point, and the centre of the circle about which the figure is described.

20. When the axis of a cone or pyramid is perpendicular to the base, it is called a *right* cone or pyramid; but if inclined it is called *oblique*.

21. *Similar cones and cylinders*, are such as have their altitudes and the diameters of their bases proportional.

22. A *sphere* is a solid bounded by one curve surface, which is everywhere equally distant from a certain point within, called the centre. It is conceived to be generated by the rotation of a semi-circle about its diameter, which remains fixed. (Fig. 61.)

23. The *axis* of a sphere is the right line about which the semi-circle revolves, and the centre is the same as that of the revolving semi-circle.

24. The *diameter* of a sphere is any right line passing through the centre, and terminated both ways by the surface.

25. The *altitude* of a solid is the perpendicular drawn from the vertex to the opposite side or base.

PROPOSITIONS.

PROP. I. If any prism be cut by a plane parallel to its base, the section will be equal and like to the base.

II. If a cylinder be cut by a plane parallel to its base, the section will be a circle, equal to the base.

III. All prisms and cylinders, of equal bases and altitudes, are equal to each other. [Euc. B. XI. Prop. 31.]

IV. Rectangular parallelopipedons, of equal altitudes, are to each other as their bases. [Euc. B. XI. Prop. 32.]

V. Rectangular parallelopipedons, of equal bases, are to each other as their altitudes.

VI. Because prisms and cylinders are as their altitudes, when their bases are equal: and, as their bases when their altitudes are equal. There-

fore, universally, when neither are equal, they are to one another as the product of their bases and altitudes: hence, also, these products are the proper numeral measures of their quantities or magnitudes.

VII. Similar prisms and cylinders are to each other as the cubes of their altitudes, or of any like linear dimensions. [Euc. B. XI., Prop. 33.]

VIII. In any pyramid a section parallel to the base is similar to the base; and these two planes are to each other as the squares of their distances from the vertex.

IX. In a right cone, any section parallel to the base is a circle; and this section is to the base as the squares of their distances from the vertex.

X. All pyramids and cones of equal bases and altitudes are equal to one another.

XI. Every pyramid is the third part of a prism of the same base and altitude. [Euc. B. XII., Prop. 10.]

XII. If a sphere be cut by a plane, the section will be a circle.

XIII. Every sphere is two-thirds of its circumscribing cylinder.

XIV. A cone, hemisphere, and cylinder of the same base and altitude are to each other as the numbers 1, 2, 3. [Euc. B. XII., Prop. 10.]

XV. All spheres are to each other as the cubes of their diameters; all these being like parts of their circumscribing cylinders. [Euc. B. XII., Prop. 18.]

XVI. There are only three sorts of regular plane figures which can be joined together, so as to form a solid angle; viz., three, four, or five *triangles*, three *squares*, and three *pentagons:* thus giving five different species of solid angles, which are those of the five *regular* or *Platonic bodies;* viz.:—

1. The *tatraedon*, (Fig. 62,) bounded by four *equilateral triangles*, each solid angle of which is formed by three *triangles*.
2. The *hexaedron*, or *cube*, (Fig. 57,) contained by six *squares*, each solid angle of which is formed by three *squares*.
3. The *octaedron*, (Fig. 63,) bounded by eight *triangles*, each solid angle of which is formed by four *triangles*.
4. The *dodecaedron*, (Fig. 64.) bounded by twelve *pentagons*, each solid angle of which is formed by three *pentagons*.
5. The *icosaedron*, (Fig. 65,) bounded by twenty triangles, each solid angle of which is formed by five *triangles*.

XVII. Only one sort of the foregoing five regular bodies, joined at their angles, can completely fill a solid space, without leaving any vacuity; viz., eight hexaedrons, or cubes.

XVIII. A sphere is to any circumscribing solid B F, (all whose planes touch the sphere,) as the surface of the sphere to the surface of the solid. (Fig. 66.)

XIX. All bodies circumscribing the same sphere, are to one another as their surfaces.

XX. The sphere is the greatest or most capacious of all bodies of equal surface.

Sect. VII.—*Practical Geometry.*

It is not intended in this place to present a complete collection of Geometrical Problems, but merely a selection of the most useful, especially in reference to the employments of Mechanics and Engineers.

The instruments for the purposes of geometrical construction, are too well known to require any description here; and their use is much easier learned by an examination of the instruments themselves, than by any written explanation.

Prob. I. *From a given point* B *in a given straight line* A C, *to draw a line perpendicular to the same.*

From B as a centre, with any radius, describe arcs cutting A C in *a* and *c*, then from *a* and *c* with any larger radius describe arcs cutting each other in *d* and *e*; then the straight line *d* B *e* will be perpendicular to A C. (Fig. 67.)

Prob. II. *To erect a perpendicular at the end of a given line.*

With any radius, and from a point somewhere above A B, describe a semicircular arc passing through the point B, at which the perpendicular is to be erected, and also cutting A B in C; then, through C and the centre of the arc produce the right line C D, cutting the arc in D, and a line joining D and B will be the perpendicular required. (Fig. 68.)

Prob. III. *To bisect any given angle* A C B.

From C as a centre, with any radius, describe an arc cutting the sides in D and E; then from D and E, as centres with the same radius, describe arcs cutting each other in F; then the straight line joining C and F will bisect the angle A C B. (Fig. 69.)

Prob. IV. *To bisect a given angle* B A P; *then to bisect its half; and so on.*

Through any point B draw B E parallel to A P, and upon B E set off the distance B C equal to B A; then join A C, and it will bisect the angle B A P.

Again, set off, upon B E, from C, C D = C A; join A D, and it will bisect C A P, or quadrisect B A P.

Again, set off, upon B E, D E = D A; join E A; and E A P will be $\frac{1}{8}$ of B A P: and so on. (Fig. 70.)

Prob. V. *At a given point* A *in a given line* A B, *to make an angle equal to a given angle* C.

From the centres A and C, with the same radius, describe the arcs D E, F G. Then, with radius D E, and centre F, describe an arc, cutting F G in G. Through G draw the line A G; and it will form the angle required. (Fig. 71.)

Prob. VI. *To divide any given angle* A B C *into three equal parts.*

From B, with any radius, describe the circle A C D A. Bisect the angle A B C by B E, and produce A B to D. On the edge of a ruler mark off the length of the radius A B. Lay the ruler on D, and move it till

one of the marks on the edge intersects B E, and the other the arc A C in G. Set off the distance C G from G to F: and draw the lines B F, and B G, they will trisect the angle A B C. (Fig. 72.)

PROB. VII. *To divide a given line* A B *into any proposed number of equal parts.*

1st *Method.* Draw any other line A C, forming any angle with the given line A B; on which set off as many of any equal parts, A D, D E, E F, F C, as the line A B is to be divided into. Join B C; parallel to which draw the other lines F G, E H, D I: then these will divide A B in the manner required. (Fig. 73.)

2nd *Method*, without drawing parallel lines. Let A B be the line which is to be divided into n equal parts. Through one extremity A draw any right line A D, upon which set off $n + 1$ equal parts, the point D being at the termination of the $(n + 1)$th part. Join D B and produce it until the prolongation B E = B D. Let F be the termination of the $(n - 1)$th part. Join F E, and the right line of junction will cut the given line A B in the point P, such that $B P = \frac{1}{n} A B$; and of course n distances each equal to B P set off upon B A, will divide it, as required*. (Fig. 74.)

PROB. VIII. *To cut off from a given line* A B, *supposed to be very short, any proportional part.*

Suppose, for example, it were required to find the $\frac{1}{12}$, $\frac{2}{12}$, $\frac{3}{12}$, &c., of the line A B, fig. 75. From the ends A and B draw A D, B C, perpendicular to A B, and divide A D into twelve equal parts; then through these divisions 1, 2, 3, &c., draw lines 1 *f*, 2 *g*, &c., parallel to A B. Draw the diagonal A C, and 1 *d* will be the $\frac{1}{12}$ of A B; 2 *c*, $\frac{2}{12}$, and so on. The same method is applicable to any other part of a given line.

PROB. IX. *To make a diagonal scale, say, of feet, inches, and tenths of an inch.*

Draw an indefinite line A B, on which set off from A to B the given length for one foot, any required number of times; and from these divisions A, C, H, B, draw A D, C E, &c., perpendicular to A B. On A D and B F set off any length ten times, and through these divisions draw lines parallel to A B; then divide A C and D E into twelve equal parts, each of which will be one inch. Draw the lines A 1, *g* 2, &c., and they will form the scale required; viz., each of the larger divisions from E to G, G to F, &c., will represent a foot; each of the twelve divisions between D and E, an inch; and the several horizontal lines parallel to R C in the triangle E C R, will be equal to $\frac{1}{10}$, $\frac{2}{10}$, $\frac{3}{10}$, &c., of an inch. (Fig. 76.)

Note.—If the scale be meant to represent feet, or any other unit, and *tenths* and *hundredths*, then D E must be divided into *ten* instead of *twelve* equal parts.

* The truth of this method is easily demonstrated. Through I the intermediate point of division, on A D, between F and D, draw I B. Then, because D B = B E, and D I = I F, I B is parallel to F P. Consequently, B P : B A :: I F : I A :: 1 : *n*, by construction.

PROB. X. *To find the centre of a circle.*

Draw any chord A B, and bisect it perpendicularly with the line R D. Then bisect R D in C, which will be the centre required. (Fig. 29.)

PROB. XI. *To divide a given circle into any number of concentric parts, equal to each other in area.*

Draw the radius A B, and on it describe the semicircle A *f e d* B. Divide A B into the proposed number of equal parts, 1, 2, 3, &c., and erect the perpendiculars 1 *d*, 2 *e*, 3 *f*, &c., meeting the semicircle in *d*, *e*, *f*, &c. Then from the centre B, and with radii B *d*, B *e*, &c., describe circles; so shall the given circle be divided into the proposed number of equal concentric parts. (Fig. 77.)

PROB. XII. *To divide a given circle into any number of parts, equal both in area and perimeter.*

Divide the diameter Q R into the proposed number of equal parts at the points S, T, V, &c.; then, on one side of the diameter describe semicircles on the diameters Q S, Q T, Q V, and on the other side of it describe semicircles on R V, R T, R S; so shall the parts 17, 35, 53, 71, be all equal, both in area and perimeter. (Fig. 78.)

PROB. XIII. *To describe the circumference of a circle through three given points*, A, B, C.

From the middle point B draw chords B A, B C, to the two other points, and bisect these chords perpendicularly by lines meeting in O, which will be the centre. Then from the centre O, at the distance of any of the points, as O A, describe a circle, and it will pass through the two other points B C, as required. (Fig. 79.)

The same method may be employed for finding the centre of a circular arc, by taking any three points in the same, as A, B, and C.

PROB. XIV. *To describe mechanically the circumference of a circle through three given points*, A, B, C, *when the centre is inaccessible; or the circle too large to be described with compasses.*

Place two rulers M N, R S, cross ways, touching the three points, A, B, C. Fix them in V by a pin, and by a transverse piece T. Hold a pencil in A, and describe the arc B A C, by moving the angle R A N, so as to keep the outside edges of the rulers against the pins B C. Remove the instrument R V N, and on the arc described mark two points, D, E, so that their distance shall be equal to the length B C. Apply the edges of the instrument against D E, and with a pencil in G describe the arc B C, which will complete the circumference of the circle required. (Fig. 80.)

Otherwise.—Let an axle of 12 or 15 inches long carry two unequal wheels A and B, of which one, A, shall be fixed, while the other, B, shall be susceptible of motion along the axle, and being placed at any assigned distance, A B, upon the paper or plane on which the circle is to be described. Then will A and B be analogous to the ends of a conic frustum, the vertex of the complete cone being the centre (O) of the circle (C D E F) which will be described by the rim, or edge, of the wheel A, as it rolls upon the proposed plane. Then it will be, as the diameter of the wheel A is to the difference of the diameters of A and B, so is the radius of the

circle proposed to be described by A, to the distance, A B, at which the two wheels must be asunder, measured upon the plane on which the circle is to be described.

The wheel B will evidently describe, simultaneously, another circle (G H I K) whose radius will be less than that of the former by A B. (Fig. 81.)

PROB. XV. *On a given chord* A B *to describe mechanically an arc of a large circle that shall contain any number of degrees.*

Place two rulers, forming an angle A C B, equal to the supplement of half the given number of degrees, and fix them in C. Place two pins at the extremities of the given chord, and hold a pencil in C; then move the edges of this instrument against the pins, and the pencil will describe the arc required. (Fig. 82.)

Suppose it is required to describe an arc of 50 degrees on the given chord A B; subtract 25 degrees (which is half the given angle,) from 180, and the difference, 155 degrees, will be the *supplement.* Then form an angle A C B of 155 degrees with the two rulers, and proceed as has been shewn above.

PROB. XVI. *To describe the segment of a circle of large radius, of which the chord* A B *and versine* C D *are given.*

Through D draw H I parallel to A B; then join A D and D B, and draw A H perpendicular to A D and B I perpendicular to B D, also draw A *d* and B *d* perpendicular to A B. Then divide A C, B C, H D, and I D, into any number of equal parts, 1, 2, 3, &c., and draw lines joining the corresponding numbers in H I and A B; also divide A *d*, B *d*, into the same number of equal parts, *a*, *b*, *c*, &c., and draw lines from the point D to these last divisions, then will the points where the lines *a* D, *b* D, *c* D, &c., cut the lines 11, 22, 33, &c., be so many points in the required segment. (Fig. 83.)

PROB. XVII. *To find the length of any given arc of a circle,* A B.

From A and B, as centres, with radius equal to a quarter of the chord of the arc A B, describe arcs cutting the given arc in C, and its chord in D; join C D, which will equal half the length of the arc A B nearly. (Fig. 84.)

PROB. XVIII. *To draw a straight line equal in length to any given portion of the circumference of a circle.*

Let A B C D be the circle, and let A *a*, *a b*, *b* B, be the portions of the circumference of which the length is required; draw the two diameters B D and A C at right angles to each other, and at the end of the latter draw the tangent line A *e*; then divide the radius E C into four equal parts, and set off three of them from C to F on the diameter produced; then draw lines from F through the points *a*, *b*, B, cutting the tangent line A *e*, in *c*, *d*, *e*; so shall the lines A *c*, *c d*, *d e*, be equal in length to the arcs A *a*, *a b*, *b* B, and the whole line A *e* equal to the quadrant A B. (Fig. 85.)

PROB. XIX. *To bisect any given triangle* A B C.

Upon any one of the sides, as A B, describe a semicircle, which bisect in the point D; then from B as a centre with radius B D describe an arc

cutting A B in E, through which point draw the line E F parallel with the side A C; then will the line E F bisect the given triangle A B C. (Fig. 86.)

PROB. XX. *To reduce a given rectilinear figure,* A B C D E F G A, *of any number of sides, to a triangle of equal area.*

Join any two alternate angles, as A C, and through the intermediate angle B, draw B H parallel to A C, cutting one of the adjoining sides in H, and join C H, then will the triangle C B *a*, added to the figure, be equal to the triangle *a* A H taken out of the same; in like manner join H D, and draw G I parallel to the same through the intermediate point G, producing it to cut the side A G (also produced) in I, and join I D. Next join D F, and through E draw a line parallel thereto, cutting the side G F produced in K, and join D K; lastly, join D G, and draw parallel to the same through the point K a line cutting the side A G produced in L, then join D L, and the triangle I D L will be equal in area to the given rectilinear figure A B C D E F G A. (Fig. 87.)

PROB. XXI. *To form a rectangle of the largest area, in a given triangle,* A B C.

Bisect any two sides A B and B C in D and E, and from those points draw lines D F and E G perpendicular to the third side A C and join D E, then will the rectangle D E F G be the largest which can be inscribed in the given triangle. (Fig. 88.)

PROB. XXII. *To form a square equal in area to a given triangle,* A B C.

On the longest side produced set off C D, equal half the perpendicular height B E; and at C erect the perpendicular C F; then on A D describe a semicircle cutting C F in G, and on C G form the square C G H I, which will be equal in area to the given triangle. (Fig. 89.)

PROB. XXIII. *To find the side of a square equal in area to a given rectangle,* A B C D.

Produce the lesser side A B of the rectangle till A E equal the longer side A D; then describe upon A E a semicircle cutting B C in F, and join A F, which will be the side of the square required. (Fig. 90.)

PROB. XXIV. *To find the side of a square equal to the difference between two given squares.*

Let the sides of the two given squares be A and B. Then draw the line C D equal to the lesser line B, and at one of its extremities erect the indefinite perpendicular D E; then with radius equal to A, and from C as a centre, describe an arc cutting this perpendicular in E; then D E will equal the side of the square required. (Fig. 91.)

PROB. XXV. *To find the side of a square equal in area to any number of given squares.*

Let the lines A, B, and C, be the sides of the given squares. Draw D E equal to A, and at the end of it erect the perpendicular E F equal to B; join D F and perpendicular to it, from the point F, erect the perpendicular G F equal to C; then join D G, which will be equal to the side of a square equal in area to the three squares on A, B, and C. (Fig. 92.)

PROB. XXVI. *To find the side of a square nearly equal in area to a given circle*, A B C D.

Draw the two diameters, A C, B D, at right angles to each other; then bisect the radius E C in F, and through D and F produce the straight line D G cutting the circle in G, then will D G equal the side of the square required. (Fig. 93.)

PROB. XXVII. *Given the side of a regular polygon of any number of sides (not exceeding twelve), to find the radius of the circle in which it may be inscribed.*

Multiply the given side of the polygon by the number which stands in column *b*, opposite its proper name in the annexed Table of Polygons; the product will be the radius required.

Thus, suppose the polygon was to be an octagon, and each side 12, then 1·3065628 × 12 = 15·6687536 would be the radius sought. Take 15·67 as a radius from a diagonal scale, describe a circle, and from the same scale, taking off 12, it may be applied as the side of an octagon in that circle.

PROB. XXVIII. *Given the radius of a circle, to find the side of any regular polygon (not having more than twelve sides) inscribed in it.*

Multiply the given radius by the number in column *c*, standing opposite the number of sides of the proposed polygon; the product is the length of the side required,

Thus, suppose the radius of the circle to be 5, then 5 × 1·732051 = 8·66025, will be the side of the inscribed equilateral triangle.

Table of Polygons.

No. of sides.	Names.	Multipliers for areas. (*a.*)	Radius of circum. cir. (*b.*)	Factors for sides. (*c.*)
3	Trigon	0·4330127	0·5773503	1·732051
4	Tetragon, or Square	1·0000000	0·7071068	1·414214
5	Pentagon	1·7204774	0·8506508	1·175570
6	Hexagon	2·5980762	1·0000000	1·000000
7	Heptagon	3·6339124	1·1523824	0·867767
8	Octagon	4·8284271	1·3065628	0·765367
9	Nonagon	6·1818242	1·4619022	0·684040
10	Decagon	7·6942088	1·6180340	0·618034
11	Undecagon	9·3656399	1·7747324	0·563465
12	Dodecagon	11·1961524	1·9318517	0·517638

CHAP. III.

MENSURATION.

SECT. I.—*Comparison of English and French Weights and Measures.*

THE following is a comparative Table of the Weights and Measures of England and France, which was published by the Royal and Central Society of Agriculture of Paris, in the Annuary for 1829, and founded on a Report, made by Mr. Mathieu, to the Royal Academy of Sciences of France, on the bill passed the 17th of May, 1824, relative to the Weights and Measures termed "Imperial," which are now used in Great Britain.

Measures of Length.

ENGLISH.		FRENCH.
1 Inch (1-36th of a yard)	=	2·539954 centimetres.
1 Foot (1-3rd of a yard)	=	3·0479449 decimetres.
Yard Imperial	=	0·91438348 metre.
Fathom (2 yards)	=	1·82876696 metre.
Pole, or perch (5½ yards)	=	5·02911 metres.
Furlong (220 yards)	=	201·16437 metres.
Mile (1760 yards)	=	1609·3149 metres.

FRENCH.		ENGLISH.
1 Millimetre	=	0·03937 inch.
1 Centimetre	=	0·393708 inch.
1 Decimetre	=	3·937079 inches.
1 Metre	=	39·37079 inches. 3·2808992 feet. 1·093633 yard.
Myriametre	=	6·2138 miles.

Square Measures.

ENGLISH.		FRENCH.
1 Yard square	=	0·836097 metre square.
1 Rod (square perch)	=	25·291939 metres square.
1 Rood (1210 yards square)	=	10·116775 ares.
1 Acre (4840 yards square)	=	0·404671 hectare.

FRENCH.		ENGLISH.
1 Metre square	=	1·196033 yard square.
1 Are	=	0·098845 rood.
1 Hectare	=	2·473614 acres.

Solid Measures.

ENGLISH.		FRENCH.
1 Pint (1-8th of a gallon)	=	0·567932 litre.
1 Quart (1-4th of a gallon)	=	1·135864 litre.
1 Gallon imperial	=	4·54345794 litres.

ENGLISH.		FRENCH.
1 Peck (2 gallons)	=	9·0869159 litres.
1 Bushel (8 gallons)	=	36·347664 litres.
1 Sack (3 bushels)	=	1·09043 hectolitre.
1 Quarter (8 bushels)	=	2·907813 hectolitres.
1 Chaldron (12 sacks)	=	13·08516 hectolitres.

FRENCH.		ENGLISH.
1 Litre	=	1·760773 pint. 0·2200967 gallon.
1 Decalitre	=	2·2009667 gallons.
1 Hectolitre	=	22·009667 gallons.

Weights.

ENGLISH TROY.		FRENCH.
1 Grain (1-24th of a pennyweight)	=	0·06477 gramme.
1 Pennyweight (1-20th of an ounce)	=	1·55456 gramme.
1 Ounce (1-12th of a pound troy)	=	31·0913 grammes.
1 Pound troy imperial	=	0·3730959 kilogramme.

ENGLISH AVOIRDUPOIS.		FRENCH.
1 Drachm (1-16th of an ounce)	=	1·7712 gramme.
1 Ounce (1-16th of a pound)	=	28·3384 grammes.
1 Pound avoirdupois imperial	=	0·4534148 kilogramme.
1 Hundred-weight (112 pounds)	=	50·78246 kilogrammes.
1 Ton (20 hundred-weight	=	1015·649 kilogrammes.

FRENCH.		ENGLISH.
1 Gramme	=	15·438 grains troy. 0·643 pennyweight. 0·03216 ounce troy.
1 Kilogramme	=	2·68027 pounds troy. 2·20548 do. avoirdupois.

Angular Measure.

In France, the centesimal division of the circle is frequently employed, in which the whole circumference is divided into 400 degrees, each degree into 100 minutes, each minute into 100 seconds, &c.

CENTESIMAL.		ENGLISH.
1 Degree	=	54 minutes.
1 Minute	=	32·4 seconds.
1 Second	=	·324 second.

ENGLISH.		CENTESIMAL.
1 Degree	=	1⅑ degree.
1 Minute	=	1·85185 minute.
1 Second	=	3·08641 seconds.

SECT. II.—*Mensuration of Superficies.*

TRIANGLES.

Let b, c, and d, represent the three sides of a triangle (see fig. 95); β, γ, and δ, the angles opposite those sides respectively; and h the perpendicular height from the vertex to the base b; then the

$$\text{area} = \tfrac{1}{2} b\, h,$$

$$\text{or} = \tfrac{1}{2} b\, c \,.\, \sin \delta = \tfrac{1}{2} c\, d \,.\, \sin \beta = \tfrac{1}{2} d\, b \,.\, \sin \gamma.$$

$$\text{Or,} = \sqrt{d^2 - \left(\frac{d^2 - c^2}{2\,b} + \frac{b}{2}\right)^2} \cdot \frac{b}{2}$$ where b is the greatest side and c the least.

If half the sum of the three sides or $\frac{b + c + d}{2} = s$, then the

$$\text{area} = \sqrt{s\,(s-b) \,.\, (s-c) \,.\, (s-d)},$$ and the

$$\log \text{ of area} = \tfrac{1}{2}\{\log s + \log (s-b) + \log (s-c) + \log (s-d)\}.$$

QUADRILATERALS, OR FOUR-SIDED FIGURES.

Square, Rectangle, Rhombus and Rhomboid:—To obtain the area, multiply the perpendicular height (h, fig. 96) by the base (b) on which it falls.

The area of a *Trapezium* is best found by dividing it into two triangles (as fig. 17), the areas of which may be found by the foregoing rules.

The area of a *Trapezoid* (fig. 16) may either be found in the same way, or by multiplying half the sum of the two parallel sides ($a + b$) by the perpendicular distance between them (h).

POLYGONS.

To obtain the area of any regular polygon, having less than twelve sides, multiply the square of one of the sides by the number found in column a, of the Table of Polygons, page 191. Or, generally, if l = the length of one of the equal sides, and n the number of them; then the

$$\text{area} = l^2 \frac{n}{4} \tan \,.\, \left(\frac{90\,n - 180}{n}\right).$$

The area of an irregular polygon may be determined by dividing it into triangles, as in fig. 97. Or by forming one triangle equal in area to it, by Prob. XX., page 190.

CIRCLES.

Let d represent the diameter, c the circumference, a the area, and $p = 3{\cdot}14159$; then the

$$\text{Diameter} = d = \frac{c}{p} = \frac{4\,a}{c} = 2\sqrt{\frac{a}{p}}.$$

$$\text{Circumference} = c = p\,d = \frac{4\,a}{d} = 2\sqrt{p\,a}.$$

$$\text{Area} = a = \frac{p\,d^2}{4} = \frac{c^2}{4\,p} = \frac{d\,c}{4} = {\cdot}7854\,d^2.$$

$$\text{and } p = \frac{c}{d} = \frac{4\,a}{d^2} = \frac{c^2}{4\,a}.$$

Circular Arcs.—If r represents the radius, and d the diameter of the circle; s the sine, and v_1 the versed sine of the arc; c the chord of half the arc, v_2 the versed sine of half the arc; and m the measure in degrees of the whole arc; then

$$\text{the length of the arc} = \cdot 0174533\, r\, m;$$

$$\text{or} = 2\,d\,\sqrt{\frac{3v_1}{3\,d - v_2}} \text{ nearly};$$

$$\text{or} = \tfrac{8}{9}\left\{5\,d\,\sqrt{\frac{5\,v_1}{5\,d - 3\,v_2}} + 4\sqrt{d\,v_2}\right\} \text{ nearly};$$

$$\text{or} = \frac{8\,c - 2\,s}{3} \text{ nearly.}$$

And the following relations between the several quantities, from which any one of them may be obtained, will be found useful, viz. :—

$$v_1 = r - \sqrt{r^2 - s^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1.)$$

$$c = \sqrt{s^2 + v_1^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2.)$$

$$s = \sqrt{r^2 - (r - v_1)^2} \quad \ldots\ldots\ldots\ldots\ldots \quad (3.)$$

$$d = \frac{s^2}{v_1} + v_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4.)$$

Circular Sectors.—Let d represent the diameter of the circle, l the length of the arc of the sector, and m its measure in degrees; then the

$$\text{area} = \tfrac{1}{2}\, r\, l.$$

$$\textit{or} = \cdot 00218\, d^2\, m.$$

Circular Segments.—Let d represent the diameter of the circle, v the versed sine, c_1 the chord of the whole arc, and c_2 the chord of half the arc; then the

$$\text{area} = \tfrac{4}{5}\left\{\sqrt{(d\,v - v^2)} + \tfrac{2}{3}\sqrt{d\,v}\right\} \text{ nearly};$$

$$\text{or} = \tfrac{4}{5}\, v\,(d\,v - \tfrac{3}{5}\, v^2) \text{ nearly};$$

$$\text{or} = \tfrac{4}{10}\, v\,(c_1 + \tfrac{4}{3}\, c_2) \text{ nearly};$$

$$\text{or} = \tfrac{4}{5}\, v\sqrt{(\tfrac{1}{4}\, c_1^2 + \tfrac{2}{5}\, v^2)} \text{ nearly.}$$

Or the area of any segment, as fig. 98, may be obtained by finding the area of the sector A B C D, and subtracting from it the area of the triangle A C D.

The area of a *circular zone*, as E F G H, may be found by subtracting the area of the segment G H I from the area of the segment E G I H F.

PARABOLA.

The area of a parabola is equal to two-thirds of the product of the base × the perpendicular height.

Parabolic Arcs.—Let x be the abscissa $a\,b$, fig. 99, measured from the vertex a, and y the corresponding right ordinate $c\,b$; then the length of the arc $c\,a\,d$ is

$$= 2\sqrt{(y^2 + \tfrac{4}{3}\, x^2)} \text{ nearly};$$

$$\text{or} = \tfrac{2}{5}\left\{\sqrt{(y^2 + \tfrac{4}{3}\, x^2)} - \frac{y^2 + \tfrac{2}{3}\, x^2}{\tfrac{1}{4}\, y}\right\}.$$

Parabolic Frustum, or Zone.—The word *zone* is here used to denote the space $c\,d\,e\,g$ (fig. 99), contained between the two parallel double ordi-

nates $c\,d$ and $e\,g$. Let y_1 = the length of the double ordinate $c\,d$, and y_2 = the length of $e\,g$, and d = the perpendicular distance between them $b\,f$; then the

$$\text{area of the zone} = \tfrac{2}{3}\,d\,\frac{y_2^{\,3} - y_1^{\,3}}{y_2^{\,2} - y_1}.$$

ELLIPSE.

The *area* is equal to the product of the transverse diameter × the conjugate diameter × ·785398.

The *periphery* or circumference is equal to the *sum* of the transverse and conjugate diameters × 1·57079.

The foregoing is only an approximation to the periphery, although sufficiently near the truth for ordinary purposes; but where greater accuracy is required the following series may be employed. Let t represent the transverse axis, c the conjugate, $p = 3{\cdot}14159$, &c., and $d = 1 - \frac{c^2}{t^2}$; then

$$p\,t\,\{1 - \frac{d}{2^2} - \frac{3\,d^2}{2^2 \cdot 4^2} - \frac{3^2 \cdot 5\,d^3}{2^2 \cdot 4^2 \cdot 6^2} - \frac{3^2 \cdot 5^2 \cdot 7\,d^4}{2^2 \cdot 4^2 \cdot 6^2 \cdot 8^2} - \text{&c.}\}$$

will be the periphery.

Elliptic Segments—To find the area of the elliptic segment $a\,b\,c$ (fig. 100), find the area of the corresponding circular segment, $d\,b\,e$, described on the same axis ($b\,f$) to which the cutting line or base of the segment $a\,c$ is perpendicular. Then, as this axis ($b\,f$) : the other axis ($g\,h$) :: the circular segment ($d\,b\,e$) : the elliptic segment ($a\,b\,c$).

Elliptic Arcs.—Let t represent the semi-transverse, and c the semi-conjugate diameters of the ellipse, and d the distance of the ordinate from the centre, then the length of the arc contained between the ordinate and the parallel semi-axis will be

$$= d\,\{1 + \frac{c^2}{6\,t^4}\,d^2 + \frac{4\,t^2\,c^2 - c^4}{40\,t^8}\,d^4 + \frac{8\,t^4\,c^2 - 4\,t^2\,c^4 + c^6}{112\,t^{12}}\,d^6 + \text{&c.}\}$$

$$\text{or make } \frac{t^2 - c^2}{t^2} = r\text{; then the}$$

$$\text{length of the arc} = d\,\sqrt{\frac{t^2 - \frac{1}{3}\,r\,d^2}{t^2 - \frac{1}{3}\,d^2}}\ \text{nearly.}$$

HYPERBOLA.

The *area* of an hyperbola or hyperbolic segment may be found as follows:—let t and c represent the semi-transverse and semi-conjugate diameters, $2\,y$ the double ordinate which cuts off the segment, and x its abcissa; also $q = \frac{x}{2\,t + x}$; then the

$$\text{area} = 2\,x\,y\,\{\tfrac{1}{3} - \frac{q}{3 \cdot 5} - \frac{q^2}{3 \cdot 5 \cdot 7} - \frac{q^3}{3 \cdot 5 \cdot 7 \cdot 9} - \text{&c.}\}$$

$$\text{or} = \frac{4\,c\,x}{15}\,\{4\sqrt{(2\,t\,x + \tfrac{3}{4}\,x^2)} + \sqrt{2\,t\,x}\}\ \text{nearly.}$$

Hyperbolic Arcs.—The notation being the same, the following approximation may be employed to obtain the length of an hyperbolic arc.

$$\text{Arc} = \frac{120\,c^2\,t + (19\,t^2 + 21\,c^2)\,4\,x}{120\,c^2\,t + (9\,t^2 + 21\,c^2)\,4\,x} + y\text{, nearly.}$$

SECT. III.—*Mensuration of Solids.*

PARALLELOPIPEDON, PRISM, OR CYLINDER.

Surface.—Multiply the perimeter of one end by the length or perpendicular height, to which add the area of the two ends, the sum will be the surface.

Solidity = the area of the base × the perpendicular height.

PYRAMID OR CONE.

Surface.—Multiply half the perimeter by the slant height, to which add the area of the base, the sum is the surface.

Solidity = the area of the base × one-third the perpendicular height.

Frustum of a Pyramid or Cone. Surface.—Multiply half the sum of the perimeters of the two ends by the perpendicular height.

Solidity.—Add a diameter or side of the greater end to one of the less, and from the square of the sum subtract the product of the said two diameters or sides; then multiply the remainder by one-third of the height, and this product by ·785398 for circles, or by the proper multiplier for polygons; the last product will be the capacity.

That is, let D equal the greater diameter, d the less, h the perpendicular height, and p = ·785398 for cones, or for any pyramid the proper multiplier from column (a) in the table at page 191, then

$$\text{Solidity} = \tfrac{1}{3}\, p\, h\, (\mathrm{D}^2 + \mathrm{D}\, d + d^2).$$

SPHERE.

Surface = the diameter × the circumference, = the square of the diameter × 3·14159, = the square of the circumference × ·3183.

Solidity = the cube of the diameter × ·5236, = the cube of the circumference × ·01688.

Spherical Segment.—Let d equal the diameter of the aphere, r the radius of the base of the segment, and h its height; then the *curved surface* = 3·14159 $d\, h$.

$$\textit{Solidity} = 0{\cdot}5236\, h^2\, (3d - 2\, h);$$

$$\text{or} = 0{\cdot}5236\, h\, (3r^2 + h^2).$$

The surface and solidity of a *spherical zone* may be obtained by taking the difference between the two segments.

CONOIDS.

A *conoid* is the solid generated by the revolution of a conic section about one of its axis, and is called a *spheroid*, *paraboloid*, or *hyperboloid*, according to the section from which it is produced.

Spheroids.—When the *ellipse* revolves about its transverse axis, it is called an *oblong* or *prolate spheroid;* when about its conjugate axis, an *oblate spheroid;* and when about any other of its diameters, a *universal spheroid*, in which latter case its figure is somewhat resembling a heart. To obtain the *solidity* of a spheroid, multiply the square of the revolving axis by the fixed axis, and the product by 0·5236.

Paraboloid.—Let y be the radius of the circular base, and x the altitude of the solid; then

$$Surface = \frac{0{\cdot}5236\,y}{x^2}\left\{(y^2 + 4x^2)^{\frac{3}{2}} - y^3\right\}.$$

$$Solidity = 1{\cdot}5708\,y^2 x.$$

Hyperboloid.—Let t equal the transverse axis, r the radius of the base, a the altitude, and p the parameter; then the

$$Solidity = \tfrac{1}{2}p^2\,\frac{t + \frac{2}{3}a}{t + a}.$$

THE REGULAR OR PLATONIC SOLIDS.

The regular or Platonic bodies are five in number, and have already been described at page 185.

1. *To find either the surface or the solid content of any of the regular bodies.*—Multiply the proper tabular area or surface (taken from column (*a*) in the following table,) by the square of the linear edge of the solid, for the *superficies*. And

Multiply the tabular solidity in column (*b*) of the table by the cube of the linear edge for the *solid content*.

Surfaces and Solidities of Regular Bodies, the side being unity or 1.

No. of sides.	Name.	Surface. (*a*)	Solidity. (*b*)
4	Tetraedron	1·7320508	0·1178513
6	Hexaedron	6·0000000	1·0000000
8	Octaedron	3·4641016	0·4714045
12	Dodecaedron	20·6457288	7·6631189
20	Icosaedron	8·6602540	2·1816950

2. *The diameter of a sphere being given, to find the side of any of the Platonic bodies, that may be either inscribed in the sphere, or circumscribed about the sphere, or that is equal to the sphere.*—Multiply the given diameter of the sphere by the proper or corresponding number, in the following table, answering to the thing sought, and the product will be the side of the Platonic body required.

The diam. of a sphere being 1; the side of a	That may be inscribed in the sphere, is	That may be circumscribed about the sphere, is	That is equal to to the sphere, is
Tetraedron	0·8164966	2·4494897	1·6439480
Hexaedron	0·5773503	1·0000000	0·8059958
Octaedron	0·7071068	1·2247447	1·0356300
Dodecaedron	0·3568221	0·4490279	0·4088190
Icosaedron	0·5257309	0·6615845	0·6214433

3. *The side of any of the five Platonic bodies being given, to find the diameter of a sphere, that may either be inscribed in that body, or circumscribed about it, or that is equal to it.*—As the respective number in the table above, under the title *inscribed, circumscribed,* or *equal,* is to 1, so is the side of the given Platonic body to the diameter of its inscribed, circumscribed, or equal sphere.

4. *The side of any one of the five Platonic bodies being given, to find the side of the other four bodies, that may be equal in solidity to that of the given body.*—As the number under the title *equal* in the last column of the table above, against the given Platonic body, is to the number under the same title, against the body whose side is sought, so is the side of the given Platonic body to the side of the body sought.

Besides these there are *thirteen* demiregular bodies, called *Solids of Archimedes.* They are described in the Supplement to *Lidonne's Tables de tous les Diviseurs des Nombres, &c.,* Paris, 1808; twelve of them were described by Abraham Sharp, in his Treatise on Polyedra.

TO FIND THE CONTENTS OF SURFACES AND SOLIDS NOT REDUCIBLE TO ANY KNOWN FIGURE, BY THE EQUIDISTANT ORDINATE METHOD.

The general rule is included in this proposition, viz. :—If any right line be divided into any *even* number of equal parts, 1, 2, 3, 4, &c., (fig. 101,) and at the points of division be erected perpendicular ordinates 1 A, 2 B, 3 C, &c., terminated by any curve A C G: then, if a be put for the sum of the first and last ordinates, 1 A, 7 G, e for the sum of the *even* ordinates, 2 B, 4 D, 6 F, &c., viz., the second, fourth, sixth., &c., and o for the sum of all the rest, 3 C, 5 E, &c., viz., the third, fifth, &c., or the *odd* ordinates, excepting the first and last: then, the common distance 1, 2, 2, 3, &c., of the ordinates being multiplied into the sum arising from the addition of s, four times e, and twice o, *one third* of the product will be the area 1 A, G 7, very nearly.

$$\text{That is, } \frac{s + 4e + 2o}{3} \cdot \text{D} = \text{area, D being} = \text{A C} = \text{C E, \&c.}$$

The same theorem will equally serve for the contents of all solids, by using the sections perpendicular to the axis instead of the ordinates. The proposition is quite accurate, for all parabolic and right lined areas as well as for all solids generated by the revolutions of conic sections or right lines about axes, and for pyramids and their frustums. For other areas and solidities it is an excellent approximation.

The greater the number of ordinates, or of sections, that are taken, the more accurately will the area or the capacity be determined. But in a great majority of cases *five* equidistant ordinates, or sections, will lead to a very accurate result.

CHAP. IV.

TRIGONOMETRY.

SECT. I.—*Definitions and Trigonometrical Formulæ.*

1. *Plane Trigonometry* is that branch of mathematics by which we learn how to determine or compute the unknown parts of a plane, or rectilinear triangle, from those which are known, when that is possible.

Every triangle consists of six parts, viz., three sides, and three angles opposite those sides. And any three of these being given (excepting only when the three angles are given,) the others may always be determined from them.

The determination of the mutual relation of the sines, tangents, secants, &c., of the sums, differences, multiples, &c., of arcs or angles; or the investigation of the connected formulæ, is also usually classed under plane trigonometry.

2. Let A C B (fig. 102,) be a rectilinear angle: if about C as a centre, with any radius C A, a circle be described, intersecting C A, C B, in A, B, the arc A B is called the *measure* of the angle A C B.

3. The circumference of a circle is supposed to be divided or to be divisible into 360 equal parts, called *degrees;* each degree into 60 equal parts, called *minutes;* each of these into 60 equal parts, called *seconds;* and so on to the minutest possible subdivisions. Of these, the first is indicated by a small circle, the second by a single accent, the third by a double accent, &c. Thus, $47^\circ\ 18'\ 34''\ 45'''$, denotes 47 degrees, 18 minutes, 34 seconds, and 45 thirds. The number of degrees, minutes, seconds, &c., contained in the arc A B of the circle described from the angular point C, and which is contained between the two legs A C, A B, is called the measure of the angle A C B, which is then said to be an angle of so many degrees, minutes, seconds, &c. Thus, since a quadrant or quarter of a circle, contains 90 degrees, and a quadrantal arc is the measure of a right angle, a right angle is said to be one of 90 degrees.

4. The *complement of an arc* is its difference from a quadrant, as B E; and the *complement of an angle* is its difference from a right angle, as E C B.

5. The *supplement of an arc* is its difference from a semicircle, as A′ E B; and the *supplement of an angle* is its difference from two right angles, as A′ C B.

6. The *sine* of an arc is a perpendicular let fall from one extremity upon a diameter passing through the other, as B D.

7. The *versed sine* or *versine* of an arc is that part of the diameter which is intercepted between the foot of the sine and the arc, as D A.

8. The *tangent* of an arc is a right line which touches it in one extremity, and is limited by a right line drawn from the centre of the circle through the other extremity, as A T.

9. The *secant* of an arc is the radial line which thus limits the tangent, as C T.

10. These are also, by way of accommodation, said to be the sine, tangent, &c., of the angle measured by the aforesaid arc, to its determinate radius.

11. The *cosine* of an arc or angle, is the sine of the complement of that arc or angle, as G B: the *cotangent* of an arc or angle is the tangent of the complement of that arc or angle, as E M. And the *co-versed sine* E G, and *cosecant* C M, are similarly the versed sine and secant of the complement.

12. The *suversine* of an arc is the versed sine of its supplement, as A D.

Note.—The following contractions are employed to express the foregoing terms, viz.:—

For the *radius* of the arc	A B	we write	*rad* A B,
sine	ditto		*sin* A B,
tangent	ditto		*tan* A B,
secant	ditto		*sec* A B,
versine	ditto		*versin* A B,
cosine	ditto		*cos* A B,
cotangent.....	ditto		*cot* A B,
cosecant	ditto		*cosec* A B,
coversine.....	ditto		*covers* A B.

SECT. II.—*General Propositions.*

I. The chord of any arc is a mean proportional between the versed sine of that arc and the diameter of the circle.

II. As radius is to the cosine of any arc, so is twice the sine of that arc to the sine of double the arc.

III. The secant of any arc is equal to the sum of its tangent, and the tangent of half its complement.

IV. The sum of the tangent and secant of any arc, is equal to the tangent of an arc exceeding that by half its complement. Or, the sum of the tangent and secant of an arc is equal to the tangent of 45° *plus* half the arc.

V. The chord of 60° is equal to the radius of the circle; the versed sine and cosine of 60° are each equal to half the radius, and the secant of 60° is equal to double the radius.

VI. The tangent of 45° is equal to the radius.

VII. The square of the sine of half any arc or angle is equal to a rectangle under half the radius and the versed sine of the whole arc; and the square of its cosine is equal to a rectangle under half the radius and the versed sine of the supplement of the whole arc or angle.

VIII. The rectangle under the radius and the sine of the sum or the difference of two arcs is equal to the sum or the difference of the rectangles under their alternate sines and cosines.

IX. The rectangle under the radius and the cosine of the sum or the difference of two arcs, is equal to the difference or the sum of the rectangles under their respective cosines and sines.

X. As the difference or sum of the square of the radius and the rectangle under the tangents of two arcs, is to the square of the radius; so is the sum or difference of their tangents, to the tangent of the sum or difference of the arcs.

XI. As the sum of the sines of two unequal arcs, is to their difference; so is the tangent of half the sum of those two arcs to the tangent of half their difference.

XII. Of any three equidifferent arcs, it will be as radius is to the cosine of their common difference, so is the sine of the mean arc, to half the sum of the sines of the extremes; and, as radius is to the sine of the common difference, so is the cosine of the mean arc to half the difference of the sines of the two extremes.

(A.) If the sine of the mean of three equidifferent arcs (radius being unity) be multiplied into twice the cosine of the common difference, and the sine of either extreme be deducted from the product, the remainder will be the sine of the other extreme.

(B.) The sine of any arc above 60°, is equal to the sine of another arc as much below 60°, together with the sine of its excess above 60°.

Cor. From this latter proposition, the sines below 60° being known, those of arcs above 60° are determinable by addition only.

XIII. In any right-angled triangle, the hypothenuse is to one of the legs, as the radius is to the sine of the angle opposite to that leg; and one of the legs is to the other as the radius is to the tangent of the angle opposite to the latter.

XIV. In any plane triangle, as one of the sides is to another, so is the sine of the angle opposite to the former to the sine of the angle opposite to the latter.

XV. In any plane triangle it will be, as the sum of the sides about the vertical angle is to their difference, so is the tangent of half the sum of the angles at the base, to the tangent of half their difference.

XVI. In any plane triangle it will be, as the cosine of the difference of the angles at the base, is to the cosine of half their sum, so is the sum of the sides about the vertical angles to the third side. Also, as the sine of half the difference of the angles at the base, is to the sine of half their sum, so is the difference of the sides about the vertical angle to the third side, or base*.

XVII. In any plane triangle it will be, as the base is to the sum of the two other sides, so is the difference of those sides to the difference of the segments of the base made by a perpendicular let fall from the vertical angle.

* These propositions were first given by *Thacker* in his *Mathematical Miscellany*, published in 1743; their practical utility has been subsequently shewn by *Professor Wallace*, in the *Edinburgh Philosophical Transactions*.

XVIII. In any plane triangle it will be, as twice the rectangle under any two sides, is to the difference of the sum of the squares of those two sides and the square of the base, so is the radius to the cosine of the angle contained by the two sides.

Cor. When unity is assumed as radius, then if A C, A B, B C, are the sides of a triangle, and C the angle opposite the side A B, this Prop. gives $\cos C = \frac{AC^2 + BC^2 - AB^2}{2CB \cdot CA}$: and similar expressions for the other angles.

XIX. As the sum of the tangents of any two unequal angles is to their difference, so is the sine of the sum of those angles to the sine of their difference.

XX. As the sine of the difference of any two unequal angles is to the difference of their sines, so is the sum of those sines to the sine of the sum of the angles.

These and other propositions are the foundation of various formulæ, for which the reader who wishes to pursue the inquiry may consult the best treatises on Trigonometry.

SECT. III.—*Solution of the Cases of Plane Triangles.*

Although the three sides and three angles of a plane triangle, when combined three and three, constitute twenty varieties, yet they furnish only *three* distinct cases in which separate rules are required.

CASE I.

When a side and an angle are two of the given parts.

The solution may be effected by Prop. XIV. of the preceding section, wherein it is affirmed that the sides of plane triangles are respectively proportional to the sines of their opposite angles.

In practice, if a *side* be required, begin the proportion with a sine, and say,

As the sine of the given angle,
Is to its opposite side;
So is the sine of either of the other angles,
To its opposite side.

If an *angle* be required, begin the proportion with a side, and say,

As one of the given sides,
Is to the sine of its opposite angle;
So is the other given side,
To the sine of its opposite angle.

The third angle becomes known by taking the sum of the two former from 180°.

Note.—It is usually best to work the proportions in trigonometry by means of the logarithms, taking the logarithm of the *first* term from the

sum of the logarithms of the *second* and *third*, to obtain the logarithm of the *fourth* term. Or, adding the *arithmetical complement* of the logarithm of the first term to the logarithms of the other two, to obtain that of the fourth.

CASE II.

When two sides and the included angle are given.

The solution may be effected by means of Props. XV. and XVI. of the preceding section.

Thus: take the given angle from 180°, the remainder will be the sum of the other two angles.

Then say,

As the sum of the given sides,
Is to their difference;
So is the tangent of half the sum of the remaining angles;
To the tangent of half their difference.

Then, secondly say,

As the cosine of half the said difference,
Is to the cosine of half the sum of the angles;
So is the sum of the given sides,
To the third, or required side.

Or,

As the sine of half the diff. of the angles,
Is to the sine of half their sum;
So is the difference of the given sides,
To the third side.

Example.—In the triangle A B C (Fig. 9) are given A C = 450, B C = 540, and the included angle C = 80°; to find the third side, and the two remaining angles. Then,

	Log (B C − A C	= 90) =	1·954243
	Log tan ($\frac{1}{2}$ A + B	= 50°) =	10·076187
			12·030430
	Log (B C + A C	= 990) =	2·995635
	Log tan ($\frac{1}{2}$ A − B	= 6° 11′) =	9·034795
Then,	Log cos ($\frac{1}{2}$ A + B	= 50°) =	9·808068
	Log (B C + A C	= 990) =	2·995635
			12·803703
	Log cos ($\frac{1}{2}$ A − B	= 6°11′) =	9·997466
	Log (A B ...	= 640·08) =	2·806237

Also, $\frac{1}{2}$ (A + B) + $\frac{1}{2}$ (A − B) = 56° 11′ = A; and $\frac{1}{2}$ (A + B) − $\frac{1}{2}$ (A − B) = 43° 49′ = B.

Here, much time will be saved in the work by taking log cos $\frac{1}{2}$ (A + B) from the tables, at the same time with log tan $\frac{1}{2}$ (A + B); and log cos $\frac{1}{2}$

(A — B) as soon as log tan ½ (A — B) is found. Observe, also, that the log of B C + A C is the same in the second operation as in the first, Thus the tables need only be opened in *five* places for both operations.

Another solution to Case II.

Supposing C to be the given angle, and C A, C B, the given sides; then the third side may be found by this theorem, viz.:—

$$A B = \sqrt{(A C^2 + B C^2 - 2 A C \cdot C B \cdot \cos C)}.$$

Thus, taking A C = 450, B C = 540, C = 80°, its cos ·1736482

$$A B = \sqrt{(450^2 + 540^2 - 2 \times 450 \times 540 \times \cdot 1736482)}$$
$$= \sqrt{\{90^2 (5^2 + 6^2 - 2 \times 5 \times 6 \times \cdot 1736482)\}}$$
$$= 90 \sqrt{50 \cdot 58118} = 90 \times 7 \cdot 112 = 640 \cdot 08, \text{ as before.}$$

CASE III.

When the three sides of a plane triangle are given, to find the angles.

1st *Method.*—Assume the longest of the three sides as base, then say, conformably with Prop. XVI., last section,

As the base,
Is to the sum of the two other sides;
So is the difference of those sides,
To the difference of the segments of the base.

Half the base added to the said difference gives the greater segment, and made less by it gives the less; and thus, by means of the perpendicular from the vertical angle, divides the original triangle into two, each of which falls under the first case.

2nd *Method.*—Find any one of the angles by means of Prop. XVIII. of the preceding section; and the remaining angles either by a repetition of the same rule, or by the relation of the sides to the sines of their opposite angles, viz.:—

$$\cos C = \frac{A C^2 + B C^2 - A B^2}{2 A C \cdot B C}; \cos B = \frac{A B^2 + B C^2 - A C^2}{2 A B \cdot B C}$$

$$\text{and } \cos A = \frac{B A^2 + A C^2 - B C^2}{2 A B \cdot A C}.$$

RIGHT-ANGLED PLANE TRIANGLES.

Right-angled triangles may (as well as others,) be solved by means of the rule to the respective case under which any specified example falls; and it will then be found, since a right angle is always one of the data, that the rule usually becomes simplified in its application.

When two of the sides are given, the third may be found by means of the property in *Geom.*, Prop. XVI., Sect. II.

$$\text{Hypoth.} = \sqrt{(\text{base}^2 + \text{perp.}^2)}$$
$$\text{Base} = \sqrt{(\text{hyp.}^2 - \text{perp.}^2)} = \sqrt{(\text{hyp.} + \text{perp.}) \cdot (\text{hyp.} - \text{perp.})}$$
$$\text{Perp.} = \sqrt{(\text{hyp.}^2 - \text{base}^2)} = \sqrt{(\text{hyp.} + \text{base}) \cdot (\text{hyp.} - \text{base.})}$$

There is another method for right-angled triangles, known by the phrase *making any side radius;* which is this.

"*To find a side.* Call any one of the sides radius, and write upon it the word *radius;* observe whether the other sides become sines, tangents, or secants, and write those words upon them accordingly. Call the word written upon each side the *name* of each side: then say,

As the *name* of the given side,
Is to the given side;
So is the *name* of the required side,
To the required side."

"*To find an angle.* Call either of the *given* sides radius, and write upon it the word *radius;* observe whether the other sides become sines, tangents, or secants, and write those words on them accordingly. Call the word written upon each side the *name* of that side. Then say,

As the side made radius,
Is to radius;
So is the other given side,
To the *name* of that side,

which determines the opposite angle."

When the numbers which measure the sides of the triangle are either under 12, or resolvable into factors which are each less than 12, the solution may be obtained, conformably with this rule, easier without logarithms than with them. For,

Let A B C (Fig. 103) be a right-angled triangle, in which A B, the base, is assumed to be radius; B C is the tangent of A, and A C its secant, to that radius; or, dividing each of these by the base, we shall have the tangent and secant of A respectively, radius being unity. Tracing in like manner the consequences of assuming B C (as fig. 104), and A C (as fig. 105), each for radius, we shall readily obtain these expressions.

1. $\frac{\text{perp.}}{\text{base}}$ = tan angle at base. (Fig. 103.)
2. $\frac{\text{hyp.}}{\text{base}}$ = sec angle at base. (Fig. 103.)
3. $\frac{\text{base}}{\text{perp.}}$ = tan angle at vertex. (Fig. 105.)
4. $\frac{\text{hyp.}}{\text{perp.}}$ = sec angle at vertex. (Fig. 105.)
5. $\frac{\text{perp.}}{\text{hyp.}}$ = sin angle at base. (Fig. 104.)
6. $\frac{\text{base}}{\text{hyp.}}$ = sin angle at vertex. (Fig. 104.)

SECT. IV.—*On the application of Trigonometry to measuring Heights and Distances.*

Trigonometry receives its principal practical application in the operations of surveying, and measuring heights and distances; as, however, the methods of its application (depending on the peculiar circumstances of

each case) are exceedingly various, we cannot lay down any general rules, but must content ourselves with giving a selection of such examples as are most likely to occur; and the principles developed in which will be sufficient to guide any person in its further application to other cases.

Example 1.

In order to find the distance between two trees, A and B (Fig. 9), which could not be directly measured because of a pool which occupied much of the intermediate space, I measured the distance of each of them from a third object, C, viz., A C = 588, B C = 672, and then at the point C took the angle A C B between the two trees = 55° 40′. Required their distance.

This is an example to Case II. of plane triangles, in which two sides, and the included angle, are given. The work, therefore, may exercise the student: the answer is 593·8.

Example 2.

Wanting to know the distance between two inaccessible objects, C and D (fig. 106), which lay in a direct line from the bottom of a tower on whose top I stood, I took the angles of *depression* of the two objects, viz., of the most remote 25½°, of the nearest 57°. What is the distance between them, the height of the tower A B being 120 feet.

H A D = 25° 30′, hence B A D = B A H − H A D = 64° 30′.
H A C = 57° 0′, hence B A C = B A H − H A C = 33° 0′.

Hence the following calculation, by means of the *natural* tangents. For, if A B be regarded as radius, B D and B C will be the tangents of the respective angles B A D, B A C, and C D the difference of those tangents. It is, therefore, equal to the product of the difference of the natural tangents of those angles into the height A B.

Thus, nat. tan 64° 30′ =	2·0965436
nat. tan 33° =	0·6494076
difference	1·4471360
multiplied by height,	120
gives distance C D =	173·6563200

*** The natural sines, tangents, &c., are easily obtained from Table IV., by subtracting 10 from the characteristics, and then finding the natural number answering to the logarithms with their characteristics so altered.

Example 3.

Standing at a measurable distance A B (Fig. 103), on a horizontal plane, from the bottom of a tower, I took the angle of elevation of the top (C); it is required from thence to determine the height of the tower.

In this case there would be given A B and the angle A, to find $BC = AB \times \tan A$.

By logarithms, when the numbers are large, it will be $\log BC = \log AB + \log \tan A$.

Note.—If angle $A = 11° 19'$ then $BC = \frac{1}{5}$ A B very nearly.

" $A = 16\ 42$ " $BC = \frac{3}{10}$ A B "

" $A = 21\ 48$ " $BC = \frac{2}{5}$ A B "

" $A = 26\ 34$ " $BC = \frac{1}{2}$ A B "

" $A = 30\ 58$ " $BC = \frac{3}{5}$ A B "

" $A = 35\ 0$ " $BC = \frac{7}{10}$ A B "

" $A = 38\ 40$ " $BC = \frac{4}{5}$ A B "

" $A = 45\ 0$ " $BC =$ A B, *exactly*.

To save the time of computation, therefore, the observer may set the instrument to one of these angles, and advance or recede, till it accords with the angle of elevation of the object; its height above the horizontal level of the observer's eye will at once be known, by taking the appropriate fraction of the distance A B.

Example 4.

Wanting to know the height of a church steeple, to the bottom of which I could not measure on account of a high wall between me and the church, I fixed upon two stations at the distance of 93 feet from each other, on a horizontal line from the bottom of the steeple, and at each of them took the angle of elevation of the top of the steeple, that is, at the nearest station 55° 54′, at the other 33° 20′. Required the height of the steeple.

Recurring to figure 106, we have given the distance C D, and the angles of elevation at C and D. The quickest operation is by means of the natural tangents, and the theorem $AB = \frac{CD}{\cot D - \cot C}$.

Thus $\cot D = \cot 33° 20' = 1{\cdot}5204261$

$C = \cot 55\ 54 = {\cdot}6770509$

Their difference $= {\cdot}8433752$

Hence $AB = \frac{93}{{\cdot}8433752} = 110{\cdot}27$ feet.

Example 5.

Wishing to know the height of an obelisk standing at the top of a regularly sloping hill, I first measured from its bottom a distance of 36

feet, and there found the angle formed by the inclined plane and a line from the centre of the instrument to the top of the obelisk 41°; but after measuring on downward in the same sloping direction 54 feet farther, I found the angle formed in like manner to be only 23° 45′. What was the height of the obelisk, and what the angle made by the sloping ground with the horizon?

The figure being constructed (see fig. 107), there are given in the triangle A C B, all the angles and the side A B, to find B C. It will be obtained by this proportion, as sin C (= 17° 15′ = B − A) : A B (= 54) :: sin A (= 23° 45′) : B C = 73·3392. Then, in the triangle D B C are known B C as above, B D = 36, C B D = 41°; to find the other angles and the side C D. Thus, first, as C B + B D : C B − B D :: tan ½(D + C) = ½(139°) : tan ½(D − C) = 42° 24½′. Hence 69° 30′ + 42° 24½′ = 112° 54½′ = C D B, and 69° 30′ − 42° 24½′ = 27° 5½′ = B C D. Then, sin B C D : B D :: sin C B D : C D = 51·86 height of the obelisk.

The angle of inclination D A E = H D A = C D B − 90° = 22° 54½′.

Remark.—If the line B D cannot be measured, then the angle D A E of the sloping ground must be taken, as well as the angles C A B and C B D. In that case D A E + 90° will be equal to C D B: so that, after C B is found from the triangle A C B, C D may be found in the triangle C B D, by means of the relation between the sides and the sines of their opposite angles.

Example 6.

Being on a horizontal plane, and wanting to ascertain the height of a tower standing on the top of an inaccessible hill, I took the angle of elevation of the top of the hill 40°, and of the top of the tower 51°, then measuring in a direct line 180 feet farther from the hill, I took in the same vertical plane the angle of elevation of the top of the tower 33° 45′. Required from hence the height of the tower.

The figure being constructed (see fig. 108), there are given, A B = 180, C A B = 33° 45′, A C B = C B E − C A E = 17° 15′, C B D = 11°, B D C = 180° − (90° − D B E) = 130°. And C D may be found from the expression C D . rad^4 = A B . sin A . sin C B D . cosec A C B . sec. D B E.

Or, using logarithms,

log A B	= 180°	=	2·255273
+ log sin A	= 33° 45′	=	9·744739
+ log sin C B D	= 11° 0′	=	9·280599
+ log cosec A C B	= 17° 15′	=	10·527914
+ log sec D B E	= 40° 0′	=	10·115746
			41·924271
	− log rad^4	=	40·000000
log C D	= 83·9983	=	1·924271

Example 7.

In order to determine the distance between two inaccessible objects A and B (Fig. 108), on a horizontal plane, we measured a convenient base, C D, of 536 yards, and at the extremities C and D took the following angles, viz., D C B = 40° 16′, B C A = 57° 40′, C D A = 42° 22′, A D B = 71° 7′. Required the distance A B.

First, in the triangle C D A are given all the angles, and the side C D to find A D. So, again, in the triangle C D B, are given all the angles, and C D to find D B. Lastly, in the triangle D A B are given the two sides A D, B D, and the included angle A D B, to find A B = 939·52 yards.

Remark.—In like manner the distances taken two and two, between any number of remote objects posited around a convenient station line, may be ascertained.

Example 8.

Suppose that in carrying on an extensive survey, the distance between two spires A and B (Fig. 109) has been found equal to 6594 yards, and that C and D are two eminences conveniently situated for extending the triangles, but not admitting of the determination of their distance by actual admeasurement: to ascertain it, therefore, we took at C and D the following angles, viz.:—

$$\begin{cases} \text{A C B} = 85^\circ\ 46' \\ \text{B C D} = 23^\circ\ 56' \end{cases} \qquad \begin{cases} \text{A D C} = 31^\circ\ 48' \\ \text{A D B} = 68^\circ\ 2' \end{cases}$$

Required C D from these data.

In order to solve this problem, construct a similar quadrilateral A c d b, assuming $c\,d$ equal to 1, 10, or any other convenient number: compute A b from the given angles, according to the method of the preceding example. Then, since the quadrilaterals A c d b, A C D B, are similar, it will be, as A b : $c\,d$:: A B : C D; from which C D is found to be equal to 4694 yards.

Example 9.

Given the angles of elevation of any distant object, taken at three places in a horizontal right line, which does not pass through the point directly below the object; and the respective distances between the stations; to find the height of the object, and its distance from either station.

Let A E C (Fig. 110) be the horizontal plane, F E the perpendicular height of the object above that plane, A, B, C, the three places of observation, F A E, F B E, F C E, the angles of elevation, and A B, B C, the given distances. Then, since the triangles A E F, B E F, C E F, are all right angled at E, the distances A E, B E, C E, will manifestly be as the cotangents of the angles of elevation at A, B, and C.

Put A B = D, B C = d, E F = x, and then express algebraically the theorem given in Geom., which in this case becomes,

$$A E^2 . B C + C E^2 . A B = B E^2 . A C + A C . A B . B C.$$

The resulting equation is

$$d x^2 (\cot A)^2 + D x^2 (\cot C)^2 = (D + d) x^2 (\mathrm{Cot}\ B)^2 + (D + d) D d.$$

From which is readily found

$$x = \sqrt{\frac{(D + d) D d}{d (\mathrm{Cot}\ A)^2 + D (\cot C)^2 - (D + d) (\cot B)^2}}.$$

Thus E F becoming known, the distances A E, B E, C E, are found, by multiplying the cotangents of A, B, and C, respectively, by E F.

Remark.—When D = d, or D + d = 2 D = 2 d, that is, when the point B is midway between A and C, the algebraic expression becomes,

$$x = d \div \sqrt{\tfrac{1}{2} (\cot A)^2 + \tfrac{1}{2} (\cot C)^2 - (\cot B)^2},$$

which is tolerably well suited for logarithmic computation. The rule may, in that case, be thus expressed.

Double the log cotangents of the angles of elevation of the extreme stations, find the natural numbers answering thereto, and take half their sum; from which subtract the natural number answering to twice the log cotangent of the middle angle of elevation: then half the log of this remainder subtracted from the log of the measured distance between the first and second, or the second and third stations, will be the log of the height of the object.

The distance from either station will be found as above.

Note.—The case explained in this example, is one that is highly useful, and of frequent occurrence. An analogous one is when the angles of elevation of a remote object are taken from the three angles of a triangle on a horizontal plane, the sides of that triangle being known, or measurable: but the above admits of a simpler computation, and may usually be employed.

Example 10.

From a convenient station P (Fig. 111), where could be seen three objects, A, B, and C, whose distances from each other were known (viz. A B = 800, A C = 600, B C = 400 yards), I took the horizontal angles A P C = 33° 45′, B P C = 22° 30′. It is hence required to determine the respective distances of my station from each object.

Here it will be necessary, as preparatory to the computation, to describe the manner of

Construction.—Draw the given triangle A B C from any convenient scale. From the point A draw a line A D to make with A B an angle equal to 22° 30′, and from B a line B D to make an angle D B A = 33° 45′. Let a circle be described to pass through their intersection D, and through the points A and B. Through C and D draw a right line to meet the circle again in P: so shall P be the point required. For, drawing P A, P B, the angle A P D is evidently = A B D, since it stands on the

same arc A D: and for a like reason B P D = B A D. So that P is the point where the angles have the assigned value.

The result of a careful construction of this kind, upon a good-sized scale, will give the values of P A, P C, P B, true to within the 200th part of each.

Manner of Computation.—In the triangle A B C, where the sides are known, find the angles. In the triangle A B D, where all the angles are known, and the side A B, find one of the other sides A D. Take B A D from B A C, the remainder, D A C, is the angle included between the two known sides, A D, A C; from which the angles A D C and A C D may be found, by Case II., p. 204. The angle C A P = 180° − (A P C + A C D). Also, B C P = B C A − A C D; and P B C = A B C + P B A = A B C + sup. A D C. Hence the three required distances are found by these proportions. As sin A P C : A C :: sin P A C : P C :: sin P C A : P A; and lastly, as sin B P C : B C :: sin B P C : B P. The results of the computation are, P A = 709·33, P C = 1042·66, P B = 934 yards.

*** The computation of problems of this kind, however, may be a little shortened by means of an analytical investigation. Those who wish to pursue this department of trigonometry may consult the treatises by *Bonnycastle*, *Gregory*, and *Woodhouse*.

Note.—If C had been nearer to P than A B, the general principles of construction and computation would be the same; and the modification in the process very obvious.

DETERMINATION OF HEIGHTS AND DISTANCES BY APPROXIMATE MECHANICAL METHODS.

1. *For Heights.*

1. *By shadows*, when the sun shines.—Set up vertically a staff of known length, and measure the length of its shadow upon a horizontal or other plane; measure also the length of the shadow of the object whose height is required. Then it will be, as the length of the shadow of the staff, is to the length of the staff itself; so is the length of the shadow of the object, to the object's height.

2. *By two rods or staves set up vertically.*—Let two staves, one, say, of 6 feet, the other of 4 feet long, be placed upon horizontal circular or square feet, on which each may stand steadily. Let A B (Fig. 112) be the object, as a tower or steeple, whose altitude is required, and A C the horizontal plane passing through its base. Let C D and E F, the two rods, be placed with their bases in one and the same line C A, passing through A, the foot of the object; and let them be moved nearer to, or farther from, each other, until the summit B of the object is seen, in the same line as D and F, the tops of the rods. Then by the principle of similar triangles, it will be, as D H (= C E) : F H :: D G (= C A) : B G; to which add A G = C D, for the whole height A B.

3. *By reflection.*—Place a vessel of water upon the ground, and recede from it, until you see the top of the object reflected from the smooth surface of the liquid. Then, since by a principle in optics, the angles of incidence and reflection are equal, it will be as your distance measured horizontally from the point at which the reflection is made, is to the height of your eye above the reflecting surface; so is the horizontal distance of the foot of the object from the vessel to its altitude above the said surface*.

4. *By means of a portable barometer and thermometer.*—Observe the altitude B, of the mercurial column, in inches, tenths, and hundredths, at the *bottom* of the hill, or other object whose altitude is required; observe, also, the altitude, b, of the mercurial column at the *top* of the object; observe the temperatures on Fahrenheit's thermometer, at the times of the two barometrical observations, and take the mean between them.

Then $55000 \times \frac{B - b}{B + b}$ = height of the hill, in feet for the temperature of 55° on Fahrenheit. Add $\frac{1}{440}$ of this result for every degree which the mean temperature exceeds 55°; subtract as much for every degree below 55°.

This will be a good approximation when the height of the hill is less than 2000 feet; and it is easily remembered, because 55°, the assumed temperature, agree with 55, the significant figures in the co-efficient; while the significant figures in the denominator of the correcting fraction are two *fours*.

5. *By an extension of the principle of page* 208.—Set the sextant, or other instrument, to the angle 45°, and find the point C (Fig. 103) on the horizontal plane, where the object A B has that elevation: then set the instrument to 26° 34′, and recede from C, in direction B C D, till the object has that elevation.

The distance C D *between the two stations will be* = A B.

So, again, if C = 40°, D = 24° 31½′, C D will be = A B.
or, „ if C = 35°, D = 22° 23′, C D „ = A B.
or, „ if C = 30°, D = 20° 6′, C D „ = A B.
or, „ if C = 20°, D = 14° 56′, C D „ = A B.
or, generally, if cot D − cot C = rad, C D „ = A B.

6. *For deviation from level.*—Let E represent the elevation of the tangent line to the earth above the true level, in feet and parts of a foot, D the distance in miles: then $E = \frac{2}{3} D^2$.

* *Leonard Digges*, in his curious work, the *Pantometria*, published in 1571, first proposed a method for the determination of altitudes by means of a geometrical square and plummet, which has been described by various later authors, as Ozanam, Donn, Hutton, &c. But, as it does not seem preferable to the methods above given, I have not repeated it here.

This gives 8 inches for a distance of one mile; and is a near approximation when the distance does not exceed 2 or 3 miles.

2. *For Distances.*

1. *By means of a rhombus set off upon a horizontal plane.*—Suppose O (Fig. 113) the object, and O B the required distance. With a line or measuring tape, whose length is equal to the side of the intended rhombus, say 50 or 100 feet, lay down one side B A in the direction B O towards the object, and B C another side in any convenient direction (for whether B be a right angle, or not, is of no consequence); and put up rods or arrows at A and C. Then fasten two ends of two such lines at A and C, and extend them until the two other ends just meet together at D; let them lie thus stretched upon the ground, and they will form the two other sides of the rhombus A D, C D. Fix a mark or arrow at R, directly between C and O, upon the line A D; and measure R D, R A upon the tape. Then it will be as R D : D C :: C B : B O, the required distance.

Otherwise. To find the length of the inaccessible line Q R.

At some convenient point B (Fig. 114) lay down the rhombus B A D C, so that two of its sides, B A, B C, are directed to the extremities of the line Q R. Mark the intersections, O and P, of A R, C Q, with the sides of the rhombus (as in the former method): then the triangle O D P will be similar to the triangle R B Q; and the inaccessible distance R Q will be found $= \frac{O P \times B A^2}{O D \times D P}$.*

Thus, if B A = B C, &c. = 100 ft., O D = 9 ft. 5 ins., D P = 11 ft. 10 ins., O P = 13 ft. 7 ins., then Q R $= \frac{10000 \times 13\frac{7}{12}}{9\frac{5}{12} \times 11\frac{10}{12}} = 1219$ feet.

2. *By means of a micrometer attached to a telescope.*—Portable instruments for the purpose of measuring extremely small angles, have been invented by Martin, Cavallo, Dollond, Brewster, and others. In employing them for the determination of distances, all that is necessary in practice is to measure the angle subtended by an object of known dimensions, placed either vertically or horizontally, at the remoter extremity of the line whose length we wish to ascertain. Thus, if there be a house, or other erection, built with bricks, of the usual size; then four courses in *height* are equal to *a foot*, and four in *length* equal to *a yard:* and distances measured by means of these will be tolerably accurate, if care be taken while observing the angle subtended by the horizontal object, to stand directly in front of it. A man, a carriage-wheel, a window, a door, &c., at the remoter extremity of the distance we wish to ascertain, may serve for an approximation. But in all cases where it is possible, let a foot, a

* For P D : D A :: A B : B R $= \frac{A B^2}{P D}$; and O D : O P :: B R : R Q $= \frac{A B^2 . O P}{O D . D P}$.

yard, or a six-feet measure, be placed vertically, at one end of the line to be measured, while the observer with his micrometer stands at the other. Then, if h be the height of the object,

$$\text{either } \tfrac{1}{2}\,h \times \cot \tfrac{1}{2} \text{ angle subtended}$$
$$\text{or } h \times \cot \text{ angle}$$

will give the distance, according as the eye of the observer is horizontally opposite to the *middle*, or to *one extremity* of the object whose angle is taken.

When a table of natural tangents is not at hand, a *very* near approximation for all angles less than *half a degree*, and a tolerably near one up to angles of *a degree*, will be furnished by the following rules.

If the distant object whose angle is taken be 1 foot in length, then

$$\left.\begin{array}{l} 3437{\cdot}73 \div \text{the angle in minutes} \\ \text{or } 206264{\cdot} \div \text{the angle in seconds} \end{array}\right\} \text{ will give the distance in feet.}$$

If the remote object be 3, 6, 9, &c., feet in length, multiply the former result by 3, 6, 9, &c., respectively.

Ex. 1. What is the distance of a man 6 feet high, when he subtends an angle of 30 seconds?

$206264 \times 6 \div 30 = 206264 \div 5 = 41252{\cdot}8$ feet $= 13750{\cdot}9$ yards, the distance required.

Ex. 2. In order to ascertain the length of a street, I put up a foot measure at one end of it, and standing at the other found that measure to subtend an angle of 2 minutes: required the length of the street.

$$3437{\cdot}73 \div 2 = 1718{\cdot}86 \text{ feet} = 572{\cdot}95 \text{ yards.}$$

3. *By means of the velocity of sound.*—Let a gun be fired at the remoter extremity of the required distance, and observe, by means of a chronometer that measures tenths of seconds, the interval that elapses between the flash and the report: then estimate the distance for one second by the following rule, and multiply that distance by the observed interval of time; the product will give the whole distance required.

At the temperature of freezing, 32°, the velocity of sound is 1100 feet per second; for lower temperatures deduct, or for higher temperatures add, half a foot per second for every degree of difference from 32° on Fahr. thermometer; the result will shew the velocity of sound, very nearly, at all such temperatures.

Thus, at the temperature of 50° the velocity of sound is,

$$1100 \times \tfrac{1}{2}\,(50 - 32) = 1109 \text{ feet.}$$

At temperature 60°, it is $1100 + \tfrac{1}{2}\,(60 - 32) = 1114$ feet.

CHAP. V.

CONIC SECTIONS.

SECT. I.—*Definitions.*

1. *Conic Sections* are the figures made by a plane cutting a cone.

2. According to the different positions of the cutting plane there arise five different figures or sections, viz., a *triangle*, a *circle*, an *ellipse*, an *hyperbola*, and a *parabola*: of which the three last are peculiarly called *Conic Sections*.

3. If the cutting plane pass through the vertex of the cone, and any part of the base, the section will be a *triangle*, as A B. (Fig. 115.)

4. If the plane cut the cone parallel to the base, or make no angle with it, the section will be a *circle*, as A B. (Fig. 116.)

5. The section is an *ellipse* when the cone is cut obliquely through both sides, or when the plane is inclined to the base in a less angle than the side of the cone is, as A B C D. (Fig. 120.)

6. The section is a *parabola* when the cone is cut by a plane parallel to the side, or when the cutting plane and the side of the cone make equal angles with the base, as P_1 A P_2. (Fig. 138.)

7. The section is an *hyperbola* when the cutting plane makes a greater angle with the base than the side of the cone makes, as P_1 A P_2. (Fig. 130.)

Note.—In all the above definitions the cone is supposed to be a *right cone.*

8. If all the sides of the cone be continued through the vertex, forming an opposite equal cone, and the plane be also continued to cut the opposite cone, this latter section is called the *opposite hyperbola* to the former, as S_1 B S_2. (Fig. 130.)

9. And if there be two other cones, with their axes in the same plane and their sides touching the sides of the former cones, then will the same plane cut all the cones and form four hyperbolas, as P_1 A P_2, R_1 C R_2, S_1 B S_2, Q_1 D Q_2 (fig. 118), each opposite pair of which are similar; these hyperbolas are said to be *conjugate* to each other, and the figure thus formed is called the *figure of the conjugate hyperbolas*, as fig. 118.

Note.—In the following definitions, the letters refer to fig. 117 for the ellipse; fig. 118 for the hyperbola; and fig. 119 for the parabola.

10. The *vertices* of any section are the points where the cutting plane meets the opposite sides of the cone, as A and B.

Cor. Hence the ellipse and the opposite hyperbolas have each two vertices; but the parabola only one; unless we consider the other as at an infinite distance.

11. The *major axis*, or *transverse diameter* of a conic section, is the line or distance A B between the vertices.

Cor. Hence the axis of a parabola is infinite in length, A B being only a part of it.

12. The *centre* O is the middle of the axis.

Cor. Hence the centre of a parabola is infinitely distant from the vertex. And of an ellipse, the axis and centre lie within the curve: but of an hyperbola, without.

13. The *minor* or *conjugate axis*, is the line C D, drawn through the centre perpendicular to the transverse axis, and bounded each way by the curve.

Cor. Hence the parabola has not any conjugate axis, unless we suppose it at an infinite distance, and infinite in length.

14. A *tangent* to a curve at any point, is a line as A_1 T_1, which touches the curve in that point; but being produced either way does not cut it.

15. A *diameter* is any right line, as A_1 B_1, drawn through the centre, and terminated on each side by the curve; and the extremities of the diameter, or its intersections with the curve, as A_1 and B_1, are its *vertices*

Cor. Hence all the diameters of a parabola are parallel to the axis, and infinite in length. Hence, also, every diameter of the ellipse and hyperbola has two vertices; but of the parabola, only one; unless we consider the other as at an infinite distance.

16. The *conjugate* to any diameter is the line drawn through the centre, and parallel to the tangent of the curve at the vertex of the diameter. So, C_1 D_1, parallel to the tangent at A_1, is the conjugate to A_1 B_1.

17. An *ordinate* to any diameter is a line parallel to its conjugate, or to the tangent at its vertex, and terminated by the diameter and curve. So, K I and K_2 A_1 are ordinates to the axis A B; and K_1 I and E_1 I_2 ordinates to the diameter A_1 B_1.

Cor. Hence the ordinates of the axes are perpendicular to it; but of other diameters, the ordinates are oblique to them.

18. An *abscissa* is a part of any diameter, contained between its vertex and an ordinate to it; as A K or B K, and A_1 E_1 or B_1 E_1.

Cor. Hence, in the ellipse and hyperbola, every ordinate has two abscissæ; but in the parabola only one; the other vertex of the diameter being infinitely distant.

19. The vertex from which the abscissæ are measured is called the *origin* of those abscissæ, and any abscissa and its ordinate are called *co-ordinates*, as A K and K I.

20. The *parameter* of any diameter is that double ordinate which is a third proportional to the transverse and conjugate axes in the ellipse or hyperbola, and to any abscissa and its ordinate in the parabola. The parameter of the transverse axis is called the *principal parameter*, or the *latus rectum*; thus, if A_1 B_1 : C_1 D_1 :: C_1 D_1 : I_2 I_4, then I_2 I_4 is the *parameter* of A_1 B_1; and if A B : C D :: C D : I_1 I_3, then I_1 I_3 is the *latus rectum*.

21. The point where the parameter cuts the transverse axis is called the *focus*, as E, F; and the distance of the focus from the nearest vertex of the same axis is called the *focal distance*, as A E, B F.

Cor. Hence, the ellipse and hyperbola have each two foci, but the

parabola only one. The foci (or burning points) were so called because all rays are united or reflected into one of them, which proceed from the other focus, and are reflected from the curve.

22. The point E is also frequently called the *pole;* and a line drawn from any point in the curve to the pole, is called the *radius vector* as E I. And the angle B E I, contained between the radius vector and the transverse axis, is called the *traced angle.*

23. The *directrix* is a right line drawn perpendicular to the transverse axis of a conic section, through an assignable point in the prolongation of that axis; such that lines drawn from any points in the curve parallel to the axis to meet the directrix, shall be to lines drawn from the same points to the focus, in a constant ratio for the same curve.

Thus, if A E : A T : : E I_2 : $I_2 y$: : E I_3 : $I_3 x$: : E I : I X, then X Y is the directrix.

In the *ellipse* A E is *less* than A T.
In the *parabola* A E is *equal* to A T.
In the *hyperbola* A E is *greater* than A T.

24. The *subtangent* to any point in a curve, is that portion of the transverse axis which is contained between the tangent and ordinate to the same point, as K_2 T_1.

25. A *normal* at any point is a line drawn from that point perpendicular to the tangent, to meet the transverse axis, as A_1 L.

26. The *Radius of Curvature* of a conic section or other curve, is the radius of that circle which is precisely of the same curvature as the curve itself, at any assigned point, or the radius of the circle which *fits* the curve and coincides with it, at a small distance on each side of the point of contact. The circle itself is called the *osculatory* circle, or the *equicurve* circle; and if the curve be of incessantly varying curvature, each point has a distinct equicurve circle, the radius of which is perpendicular to the tangent at the point of contact.

27. An *asymtote* is a right line towards which a certain curve line approaches continually nearer and nearer, yet so as never to meet, except both be produced indefinitely. The hyperbola has two asymptotes, as U V, W Z.

CHAPTER VI.

LAND MEASURING.

We cannot enter upon any calculation connected with Land that is not more or less dependent upon the admeasurement of its surface, or, in more technical terms, its "*superficial area;*" how much more important then, than is ordinarily supposed, does it become that the very simple operations necessary to arrive at a correct result should be properly understood by those who affect to practise this particular branch of science. No extraordinary ability or power of genius, nothing out of the common way in point of education and mental attainments, no laborious application to study, nor any great amount of previous practice, is requisite to produce a competent "Land Measurer." I do not mean to say that all these are not advantages which will give a man possessing them superiority over another who does not possess them; but they are not at all indispensable; and I will endeavour to expound in simple language the rules requisite to be understood to enable any person, though of mean ability, who can perform the four fundamental rules of arithmetic, (or by the aid of Tables I published ten years since, or the Tables I will annex to this article, addition only), to measure accurately any piece of land that may come in his way although he may not be able to do it quickly, so as to turn to profitable pecuniary account the knowledge he has thus acquired.

I must not here be misunderstood. While all I have said above applies to "*Land Measuring,*" not one word is applicable to "Land Surveying;" that is a totally different branch of science, requiring long practice and a thoroughly perfect scientific education.

By "Land Surveying" I mean the admeasurement, by an infinity of instrumental and other contrivances, of the geographical and physical features of the earth's surface, embracing in their widest scope the operations of "Surveying, Mapping, and Levelling."

In extensive operations, land is generally measured with a chain of 100 links, known as Gunter's Chain, from the name of its inventor, the Rev. Edward Gunter, who was born in 1680, and died in 1726, so that it must have been in use upwards of 125 years. The chief advantage of the use of this chain is the facility it affords in squaring or casting the dimensions, 100,000 square links, or 10 square chains, being equal to one statute acre. If, however, the

results of operations in other measures are conveniently tabulated, this advantage of Gunter's Chain is superseded, and the non-professional "Land Measurer" is at liberty to take the dimensions in that measure with which he is most familiar. Country gentlemen, farmers, and indeed all classes of the community, being more generally acquainted with the standard yard, it is my intention to lay down the principles of Land Measuring without reference to any particular kind of measure used, and then to annex thereto a correctly computed Table of results, in statute acres, of dimensions taken in yards. These Tables will, as I have previously stated, entirely obviate the necessity of all calculation in cases when the pieces of land do not exceed 100 yards square, and will render dimensions in yards equally as convenient as those in chains and links.

Rules.

1. If the piece of land to be measured is in the form of a square or rectangle, that is, having four right angles, and all its sides parallel, its area is found by multiplying its length by its width. (*Vide* Mensuration of Superficies.)

2. If the piece of land to be measured is triangular, the length of the base multiplied by one-half the perpendicular, or one-half of the base multiplied by the perpendicular, will give the area; or, what is the same thing, the full base multiplied by the perpendicular, will give twice the area of the triangle. (*Vide* Mensuration of Superficies.)

3. If the piece of land has two of its sides parallel and at right angles with the base, add the two parallel sides together, and multiply one-half their sum by the base or side running at right angles to them, the product will be the area; or multiply the sum of the two sides by the base, and take half the product for the area.

Example 1.

A square piece of land is 4 long and 4 wide, what is its area? (Fig. 125.)

4 long
multiplied by 4 wide

gives . . . 16 superficial area.

I have endeavoured to render this result plainly apparent by dividing the figure into squares and numbering them, from which it will at once be seen that the area of the figure must be 16 squares of whatever measure the dimensions were taken in.

Ex. 2.—What is the content of the triangular piece of land whose base is 8 and perpendicular 4? (Fig. 126.)

	8	base	or 4	half base
multiplied by	2	half perpendicular	4	perpendicular
gives	16	superficial content.	16	area.

or 8 base
4 perpendicular

2) 32 twice area

gives 16 required area.

This is also rendered clearly apparent on the figure, by which it is shewn that the triangle A B C contains 12 perfect squares and 8 half-squares. It also shews that the two triangles wanting to form a rectangle of the same dimensions contain, in the aggregate, the same number of squares and half-squares as the triangle; thus illustrating, in the plainest manner, that one-half the area of the rectangle is the area of the triangle.

Ex. 3.—Required the area of the rhomboid whose base is 4, and its parallel sides 4 and 8 respectively. (Fig. 127.)

	4	height of one side
added to . .	8	height of opposite side
divided by	2) 12	
gives . . .	6	mean height
multiplied by	4	base
gives . . .	24	area.

or,	4	
added to . .	8	
	12	sum of the sides
multiplied by	4	base
divided by	2) 48	
gives . . .	24	area.

The figures shew that 6 must be the mean height, the square A and the two half squares a a, rejected, being equal to the square B, and the two half squares b b, taken in.

The previous rules form the fundamental ones for measuring land, but it is very unusual indeed to meet with just such figures

in practice; it does not unfrequently happen that a four-sided field is met with, but then it scarcely ever occurs that the sides are parallel to each other, or if so, that the angles are right angles; even should that be the case, it is not possible to be certain of the fact, without verifying it by some process that would take as much time as would be required to measure the field; the rule then is to divide the field into several imaginary mathematical figures, and to take such dimensions as may be required to produce the area. The triangle will be found to be the most useful of all others for this purpose, or a trapezium divided into two triangles by the "diagonal," which thus becomes a base common to both triangles, and will consequently give the area of the trapezium if multiplied into half the sum of the two perpendiculars of the triangle.

Ex. 4.—Required the Content of the Field in the form of a Trapezium, whose dimensions in Links are as given in Fig. 128.

Note.—In measuring the base A B, it was found that the first perpendicular to the corner E, sprang at the point C 422 links from A, and a mark was there left until the perpendicular could be measured; (it is very dangerous to the accuracy of the work to discontinue measuring on one line, to measure another, before the first line is completed; the insertion of the figures in the wrong places, and mixing the arrows which denote the number of chains, are among the most fruitful sources of error to an unpractised person in such cases.) Continuing the diagonal the perpendicular to the corner, F was found to spring at the point D 830 links from A*. Continuing the total length, the base A B was found to be 1142 links. The chain was then taken to F, and the perpendicular F D was measured, equal 460 links; and then the perpendicular from C to E, and found to be 480 links, which completed the operation.

Calculation.

add	460	
	480	
divide by 2)	940	sum of perpendiculars
	470	half sum of perpendiculars.

* The insertion of the distances on the diagonal at which the perpendiculars rise are not at all required in the computation of the area, but it is always worth while to enter them in the Field Book, as they enable an approximate plot of the field to be drawn, if at any future time such may be desirable. I once measured field by field the parish of Walton-upon-Thames, containing 7300 acres, and by attending to this particular in keeping the Field Notes, I was enabled some two or three years subsequently, at my leisure, to plot a very tolerable map of that parish.—E. R.

multiply	1142	diagonal
by	470	half sum of perpendiculars
	79940	
	4568	
acres	5,36740	product in square links
	4	
rood	1,46960	
	40	
perches	18,78400	

The area 536740 square links is reduced into acres, roods, and perches, by dividing by 100,000 the number of square links in an acre; this is readily done by cutting off the five right-hand figures; the figure 5 remaining on the left-hand being acres, and those on the right decimals of an acre, which by multiplying by 4 (the number of roods in an acre) and again cutting off five figures, leaves one rood on the left of the decimal dot—the decimals of a rood being multiplied by 40 (the number of perches in a rood), and the five decimals again pointed off, leave 18 perches and ·78400 decimals of a perch.

The answer, therefore, is 5A. 1R. 18·7P.

To facilitate this reduction of square links, a Table is annexed, shewing the several roods and perches in any decimal of an acre.

It is very easy to reduce them mentally by committing the following particulars to memory.

·00625	is 1	perch
·01250	is 2	„
·02500	is 4	„
·05000	is 8	„
·10000	is 16	„
·20000	is 32	„
·25000	is 1	rood
·50000	is 2	roods
·75000	is 3	roods

In our previous example, this is the kind of mental calculation we should have to carry on.

We see that the given decimal ·36740 is more than one rood; therefore, we set down one rood, and at a glance we discover we have left ·11740 ·10000 of which we know to be 16

·01250 2

and the remainder nearly 1

19 per^{cs} nearly

By the assistance of some Tables published by me in 1842,

under the title of "*Ryde's Pocket Companion and Ready Reckoner,*" the calculation of the previous example would have been as under.

The Tables rising in value, every separate link up to 1000, the half of the diagonal or odd number would have been taken (to bring it within the scope of the Tables, and thus save one line of addition,) and the sum of the perpendiculars. Thus,

	at page 115	A.	R.	P.
$\frac{1142}{2}$ = 571	by 900 =	5	0	22·2
„	by 40 =	0	0	36·5
		5	1	18·7

otherwise it would have stood

at page 94			
470 by 1100 =	5	0	27·2
„ by 40 =	0	0	30·
„ by 2 =	0	0	1·5
	5	1	18·7

The only advantage of the former arrangement over the latter being, the saving of one line, effected in the addition of the quantities.

Ex. 5.—What is the Content of the piece of Land whose dimensions are marked upon figure 129?

First, we have the diagonal A B = 1034, and the two perpendiculars C E and D F = 411 and 395 respectively; then on the line B E, between it and the curved fence, we have, first, a triangle B I K, whose base B I is 100, and perpendicular I K 66; next a rhomboid H I K L, whose base I H is the difference between 300 and 100, and whose perpendiculars H L and I K are 6 and 20 respectively; then a rectangle G H L M, whose base H G is the difference between 700 and 300, and whose perpendiculars H L and G M are 20; and lastly, we have a triangle E G M, whose base G E is the difference between 960 and 700, and whose perpendicular G M is 20.

Calculation.

$\frac{1034}{2}$ = 517 × (411 + 395 = 806)

2) 100

50 half-base
6 perp.

300 Tri. B I K.

		517	½-diagonal.
		806	sum of perp.
		3102	
		41360	
		4·16702	area of trapezium A E B F.
20	400 base	300	Triangle B I K.
6	20 perp.	2600	Rhomboid H I K L.
2)26	8000	8000	Rectangle G H L M.
13 ½-perp.	260	2600	Triangle E G M.
200	10 ½-perp.	4·30202	Total area of field.
2600	2600		

By the Table of Decimals of an acre ·30052 = 1r. 8p.
Answer 4a. 1r. 8p.

By "Ryde's Pocket Companion and Ready Reckoner."

				A.	R.	P.	
At page	104,	517 by	806 =	4	0	26·6	Trap. A E B F.
„	10,	50 „	6 =	0	0	0·4	Tri. B I K.
„	3,	13 „	200 =	0	0	4·1	Rhom. H I K L.
„	80,	400 „	20 =	0	0	12·8	Rec. G H L M.
„	52,	260 „	10 =	0	0	4·1	Tri. E G M.
			Answer	4	1	8·	

Other Examples might be added, with all the fences crooked, but it is considered unnecessary, as every distinct fence would have to be treated in a similar manner to the fence B K L M E, in our last Example.

R.	P.	Dec.	R.	P.	Dec.	R.	P.	Dec.	R.	P.	Dec.
0	1	.00625	1	1	.25625	2	1	.50625	3	1	.75625
0	2	.01250	1	2	.26250	2	2	.51250	3	2	.76250
0	3	.01875	1	3	.26875	2	3	.51875	3	3	.76875
0	4	.02500	1	4	.27500	2	4	.52500	3	4	.77500
0	**5**	**.03125**	**1**	**5**	**.28125**	**2**	**5**	**.53125**	**3**	**5**	**.78125**
0	6	.03750	1	6	.28750	2	6	.53750	3	6	.78750
0	7	.04375	1	7	.29375	2	7	.54375	3	7	.79375
0	8	.05000	1	8	.30000	2	8	.55000	3	8	.80000
0	9	.05625	1	9	.30625	2	9	.55625	3	9	.80625
0	**10**	**.06250**	**1**	**10**	**.31250**	**2**	**10**	**.56250**	**3**	**10**	**.81250**
0	11	.06875	1	11	.31875	2	11	.56875	3	11	.81875
0	12	.07500	1	12	.32500	2	12	.57500	3	12	.82500
0	13	.08125	1	13	.33125	2	13	.58125	3	13	.83125
0	14	.08750	1	14	.33750	2	14	.58750	3	14	.83750
0	**15**	**.09375**	**1**	**15**	**.34375**	**2**	**15**	**.59375**	**3**	**15**	**.84375**
0	16	.10000	1	16	.35000	2	16	.60000	3	16	.85000
0	17	.10625	1	17	.35625	2	17	.60625	3	17	.85625
0	18	.11250	1	18	.36250	2	18	.61250	3	18	.86250
0	19	.11875	1	19	.36875	2	19	.61875	3	19	.86875
0	**20**	**.12500**	**1**	**20**	**.37500**	**2**	**20**	**.62500**	**3**	**20**	**.87500**
0	21	.13125	1	21	.38125	2	21	.63125	3	21	.88125
0	22	.13750	1	22	.38750	2	22	.63750	3	22	.88750
0	23	.14375	1	23	.39375	2	23	.64375	3	23	.89375
0	24	.15000	1	24	.40000	2	24	.65000	3	24	.90000
0	**25**	**.15625**	**1**	**25**	**.40625**	**2**	**25**	**.65625**	**3**	**25**	**.90625**
0	26	.16250	1	26	.41250	2	26	.66250	3	26	.91250
0	27	.16875	1	27	.41875	2	27	.66875	3	27	.91875
0	28	.17500	1	28	.42500	2	28	.67500	3	28	.92500
0	29	.18125	1	29	.43125	2	29	.68125	3	29	.93125
0	**30**	**.18750**	**1**	**30**	**.43750**	**2**	**30**	**.68750**	**3**	**30**	**.93750**
0	31	.19375	1	31	.44375	2	31	.69375	3	31	.94375
0	32	.20000	1	32	.45000	2	32	.70000	3	32	.95000
0	33	.20625	1	33	.45625	2	33	.70625	3	33	.95625
0	34	.21250	1	34	.46250	2	34	.71250	3	34	.96250
0	**35**	**.21875**	**1**	**35**	**.46875**	**2**	**35**	**.71875**	**3**	**35**	**.96875**
0	36	.22500	1	36	.47500	2	36	.72500	3	36	.97500
0	37	.23125	1	37	.48125	2	37	.73125	3	37	.98125
0	38	.23750	1	38	.48750	2	38	.73750	3	38	.98750
0	39	.24375	1	39	.49375	2	39	.74375	3	39	.99375
1	**0**	**.25000**	**2**	**0**	**.50000**	**3**	**0**	**.75000**			

Required the content of the field whose dimensions in yards are as shewn upon fig. 130.

$\frac{14}{2}$ = 7 ½-perp.
37 = base.
259 Tri. B.

$\frac{198 - 160}{2} = \frac{38}{2} = 19$ = ½-base
19
171
19
361 Tri. C.

$\frac{27 + 19}{2} = \frac{46}{2} = 23$ = ½-perp.
160 — 76 = 84 base
92
184
1932 Rhomboid D.

$\frac{76}{2}$ = 38 ½-base
27 perp.
266
76
1026 Tri. E.

Yards.
$\frac{198}{2}$ = 99 half-base
88 perp.
792
792
8712 Triangle A.
259 Tri. B.
361 Tri. C.
1932 Rhom. D.
1026 Tri. E.
12290 area in square yards.

4840) 12290 (2 acres.
9680
2610
4
4840) 10440 (2 roods.
9680
760
40
4840) 30400 (6·28 perches
29040
13600
9680
39200
38720
480

By the new Tables:—

	A.	R.	P.
88 yards by 99 =	1	3	8
7 „ 37 =	0	0	8.56
19 „ 19 =	0	0	11.93
23 „ 84 =	0	1	23.87
38 „ 27 =	0	0	33.92
Answer . .	2	2	6.28

Note.—The reduction of square yards into acres, roods, and perches is given in this case to illustrate the method of doing it by figures; for the future we shall only employ the Tables.

Required the Area of the Field whose dimensions in yards are as marked upon fig. 131.

By the Tables.

$\frac{198}{2} \times 116 + 46 = 99 \times 162$*						
	$99 \times 100 =$	2	0	7·27	} Trap. A.	
	$99 \times 62 =$	1	1	2·91		
$\frac{186}{2} \times 127 + 68 = 93 \times 195$*						
	$93 \times 100 =$	1	3	27·44	} Trap. B.	
	$93 \times 95 =$	1	3	12·07		
$\frac{2+8}{2} \times 55 =$	$5 \times 55 =$	0	0	9·09	Rhom. C.	
$\frac{8+4}{2} \times 134 - 55 =$	$6 \times 79 =$	0	0	15·67	Rhom. D.	
†$\frac{7+5}{2} \times 27 =$	$6 \times 27 =$	0	0	5·36	Rhom. E.	
‡ $\frac{66}{2} \times 11 =$	$33 \times 11 =$	0	0	12·10	Tri. F.	
$\frac{157-87}{2} = \frac{70}{2} \times 4 = 35 \times$	$4 =$	0	0	4·63	Tri. G.	
Total Contents . .		7	1	16·54		

What are the respective quantities of four pieces of Harvest Work, whose dimensions in yards are severally, as marked on fig. 132?

Note.—We may here remark, that in narrow slips of land, such as is represented in this field, it is sufficiently accurate for ordinary purposes, if the mean length is ascertained by measuring up the middle of the slip, and the width is taken as near to either end as possible, about at right angles with the centre length, and averaged for a mean width.

* The Tables being limited to 100 yards in extent an extra line in the casting is required in each of these two figures.

† This figure is not strictly a mathematical one; it will be observed, the mean length is taken and the mean width: the field represented, is an actual field, in the parish of Walton.

‡ Here is another little irregularity of small importance; the 11 yards may not be quite at right angles with the base, but not sufficiently at variance to produce any practical consequence.

By the Table.

		A.	R.	P.	
$\frac{25 + 31}{2} = \frac{56}{2} = 28 \times 97 =$		0	2	9·79	Trap. A.
$\frac{33 + 43}{2} = \frac{76}{2} = 38 \times 94 =$		0	2	38·08	Trap. B.
$\frac{48 + 46}{2} = \frac{94}{2} = 47 \times 96 =$		0	3	29·16	Trap. C.
$\frac{32 + 34}{2} = \frac{66}{2} = 33 \times 97 =$		0	2	25·82	Trap. D.
Total Contents . .		2	3	22·85	

The little instrument used for erecting perpendiculars is called a Cross. The most simple one that can be constructed, and the most convenient because the most portable, consists of a round piece of box-wood, about four inches in diameter, and three-quarters of an inch in thickness; it has a hole in the centre, through which it may be slipped on to the offset rod, to a suitable height when stuck in the ground for a man's eye to look into. Two grooves at right angles with each other are cut into it, as shewn on Fig. 133; a thin piece of vernier is stuck on to the top of it, and when on the staff it appears as Fig. 134. To prove the accuracy of the Cross, look into groove AB, Fig. 135, and direct an assistant to set up a stick C; look through the other groove D E, and have another stick set up at F: twist the Cross round on the offset rod until the stick at F can be seen through the groove A B; then if the stick at C is seen through the groove D E, the Cross is obviously correct.

Tables of Land Measure, by dimensions taken in yards.

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
1 by 1	0	0	0.03	1 by 65	0	0	2·15	2 by 30	0	0	1.98
2	0	0	0.07	66	0	0	2.18	31	0	0	2.05
3	0	0	0·1	67	0	0	2.21	32	0	0	2.12
4	0	0	0.13	68	0	0	2.25	33	0	0	2.18
5	0	0	0.16	69	0	0	2.28	34	0	0	2.25
6	0	0	0.2	70	0	0	2.31	35	0	0	2.31
7	0	0	0.23	71	0	0	2.35	36	0	0	2.38
8	0	0	0.26	72	0	0	2.38	37	0	0	2.45
9	0	0	0.3	73	0	0	2.41	38	0	0	2.51
10	0	0	0.33	74	0	0	2.45	39	0	0	2.58
11	0	0	0.36	75	0	0	2.48	40	0	0	2.64
12	0	0	0.4	76	0	0	2.51	41	0	0	2.71
13	0	0	0.43	77	0	0	2.55	42	0	0	2.78
14	0	0	0.46	78	0	0	2·58	43	0	0	2.84
15	0	0	0.5	79	0	0	2·61	44	0	0	2.91
16	0	0	0.53	80	0	0	2·64	45	0	0	2.98
17	0	0	0.56	81	0	0	2.68	46	0	0	3.04
18	0	0	0.6	82	0	0	2.71	47	0	0	3.11
19	0	0	0.63	83	0	0	2.74	48	0	0	3.17
20	0	0	0·66	84	0	0	2.78	49	0	0	3.24
21	0	0	0.69	85	0	0	2.81	50	0	0	3.31
22	0	0	0.73	86	0	0	2·84	51	0	0	3.37
23	0	0	0.76	87	0	0	2·88	52	0	0	3.44
24	0	0	0.79	88	0	0	2·91	53	0	0	3.50
25	0	0	0.83	89	0	0	2·94	54	0	0	3.57
26	0	0	0.86	90	0	0	2·98	55	0	0	3.64
27	0	0	0.89	91	0	0	3·01	56	0	0	3.7
28	0	0	0.93	92	0	0	3·04	57	0	0	3.77
29	0	0	0.96	93	0	0	3·07	58	0	0	3.83
30	0	0	0.99	94	0	0	3·11	59	0	0	3.9
31	0	0	1.02	95	0	0	3·14	60	0	0	3.97
32	0	0	1.06	96	0	0	3·17	61	0	0	4.03
33	0	0	1.09	97	0	0	3·21	62	0	0	4.1
34	0	0	1·12	98	0	0	3.24	63	0	0	4.17
35	0	0	1.16	99	0	0	3·27	64	0	0	4.23
36	0	0	1.19	100	0	0	3.31	65	0	0	4.3
37	0	0	1.22	2 by 2	0	0	0.13	66	0	0	4.36
38	0	0	1.26	3	0	0	0.2	67	0	0	4.43
39	0	0	1.29	4	0	0	0.26	68	0	0	4.5
40	0	0	1.32	5	0	0	0.33	69	0	0	4.56
41	0	0	1.36	6	0	0	0.4	70	0	0	4.63
42	0	0	1.39	7	0	0	0.46	71	0	0	4.69
43	0	0	1.42	8	0	0	0.53	72	0	0	4.76
44	0	0	1.45	9	0	0	0.6	73	0	0	4.83
45	0	0	1.49	10	0	0	0.66	74	0	0	4.89
46	0	0	1.52	11	0	0	0.73	75	0	0	4.96
47	0	0	1.55	12	0	0	0.79	76	0	0	5.02
48	0	0	1.59	13	0	0	0.86	77	0	0	5.09
49	0	0	1.62	14	0	0	0.93	78	0	0	5.16
50	0	0	1.65	15	0	0	0.99	79	0	0	5.22
51	0	0	1.69	16	0	0	1.06	80	0	0	5.29
52	0	0	1.72	17	0	0	1.12	81	0	0	5.36
53	0	0	1.75	18	0	0	1.19	82	0	0	5.42
54	0	0	1.79	19	0	0	1.26	83	0	0	5.49
55	0	0	1.82	20	0	0	1.32	84	0	0	5.55
56	0	0	1.85	21	0	0	1.39	85	0	0	5.62
57	0	0	1.88	22	0	0	1.45	86	0	0	5.69
58	0	0	1.92	23	0	0	1.52	87	0	0	5.75
59	0	0	1.95	24	0	0	1.59	88	0	0	5.82
60	0	0	1.98	25	0	0	1.65	89	0	0	5.88
61	0	0	2.02	26	0	0	1.72	90	0	0	5.95
62	0	0	2.05	27	0	0	1.79	91	0	0	6.02
63	0	0	2.08	28	0	0	1.85	92	0	0	6.08
64	0	0	2.12	29	0	0	1.92	93	0	0	6.15

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
2 by 94	0	0	6.21	3 by 60	0	0	5.95	4 by 27	0	0	3.57
95	0	0	6.28	61	0	0	6.05	28	0	0	3.7
96	0	0	6.35	62	0	0	6.15	29	0	0	3.83
97	0	0	6.41	63	0	0	6.25	30	0	0	3.97
98	0	0	6.48	64	0	0	6.35	31	0	0	4.1
99	0	0	6.55	65	0	0	6.45	32	0	0	4.23
100	0	0	6.61	66	0	0	6.55	33	0	0	4.36
3 by 3	0	0	0.3	67	0	0	6.64	34	0	0	4.5
4	0	0	0.4	68	0	0	6.74	35	0	0	4.63
5	0	0	0.5	69	0	0	6.84	36	0	0	4.76
6	0	0	0.6	70	0	0	6.94	37	0	0	4.89
7	0	0	0.69	71	0	0	7.04	38	0	0	5.02
8	0	0	0.79	72	0	0	7.14	39	0	0	5.16
9	0	0	0.89	73	0	0	7.24	40	0	0	5.29
10	0	0	0.99	74	0	0	7.34	41	0	0	5.42
11	0	0	1.09	75	0	0	7.44	42	0	0	5.55
12	0	0	1.19	76	0	0	7.54	43	0	0	5.69
13	0	0	1.29	77	0	0	7.64	44	0	0	5.82
14	0	0	1.39	78	0	0	7.74	45	0	0	5.95
15	0	0	1.49	79	0	0	7.83	46	0	0	6.08
16	0	0	1.59	80	0	0	7.93	47	0	0	6.21
17	0	0	1.69	81	0	0	8.03	48	0	0	6.35
18	0	0	1.79	82	0	0	8.13	49	0	0	6.48
19	0	0	1.88	83	0	0	8.23	50	0	0	6.61
20	0	0	1.98	84	0	0	8.33	51	0	0	6.74
21	0	0	2.08	85	0	0	8.43	52	0	0	6.88
22	0	0	2.18	86	0	0	8.53	53	0	0	7.01
23	0	0	2.28	87	0	0	8.63	54	0	0	7.14
24	0	0	2.38	88	0	0	8.73	55	0	0	7.27
25	0	0	2.48	89	0	0	8.83	56	0	0	7.4
26	0	0	2.58	90	0	0	8.93	57	0	0	7.54
27	0	0	2.68	91	0	0	9.02	58	0	0	7.67
28	0	0	2.78	92	0	0	9.12	59	0	0	7.8
29	0	0	2.88	93	0	0	9.22	60	0	0	7.93
30	0	0	2.98	94	0	0	9.32	61	0	0	8.07
31	0	0	3.07	95	0	0	9.42	62	0	0	8.2
32	0	0	3.17	96	0	0	9.52	63	0	0	8.33
33	0	0	3.27	97	0	0	9.62	64	0	0	8.46
34	0	0	3.37	98	0	0	9.72	65	0	0	8.6
35	0	0	3.47	99	0	0	9.82	66	0	0	8.73
36	0	0	3.57	100	0	0	9.92	67	0	0	8.86
37	0	0	3.67	4 by 4	0	0	0.53	68	0	0	8.99
38	0	0	3.77	5	0	0	0.66	69	0	0	9.12
39	0	0	3.87	6	0	0	0.79	70	0	0	9.26
40	0	0	3.97	7	0	0	0.93	71	0	0	9.39
41	0	0	4.07	8	0	0	1.06	72	0	0	9.52
42	0	0	4.17	9	0	0	1.19	73	0	0	9.65
43	0	0	4.26	10	0	0	1.32	74	0	0	9.79
44	0	0	4.36	11	0	0	1.45	75	0	0	9.92
45	0	0	4.46	12	0	0	1.59	76	0	0	10.05
46	0	0	4.56	13	0	0	1.72	77	0	0	10.18
47	0	0	4.66	14	0	0	1.85	78	0	0	10.31
48	0	0	4.76	15	0	0	1.98	79	0	0	10.45
49	0	0	4.86	16	0	0	2.12	80	0	0	10.58
50	0	0	4.96	17	0	0	2.25	81	0	0	10.71
51	0	0	5.06	18	0	0	2.38	82	0	0	10.84
52	0	0	5.16	19	0	0	2.51	83	0	0	10.98
53	0	0	5.26	20	0	0	2.64	84	0	0	11.11
54	0	0	5.36	21	0	0	2.78	85	0	0	11.24
55	0	0	5.45	22	0	0	2.91	86	0	0	11.37
56	0	0	5.55	23	0	0	3.04	87	0	0	11.5
57	0	0	5.65	24	0	0	3.17	88	0	0	11.64
58	0	0	5.75	25	0	0	3.31	89	0	0	11.77
59	0	0	5.85	26	0	0	3.44	90	0	0	11.9

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
4 by 91	0	0	12.03	5 by 59	0	0	9.75	6 by 28	0	0	5.55
92	0	0	12.17	60	0	0	9.92	29	0	0	5.75
93	0	0	12.3	61	0	0	10.08	30	0	0	5.95
94	0	0	12.43	62	0	0	10.25	31	0	0	6.15
95	0	0	12.56	63	0	0	10.41	32	0	0	6.35
96	0	0	12.69	64	0	0	10.58	33	0	0	6.55
97	0	0	12.83	65	0	0	10.74	34	0	0	6.74
98	0	0	12.96	66	0	0	10.91	35	0	0	6.94
99	0	0	13.09	67	0	0	11.07	36	0	0	7.14
100	0	0	13.22	68	0	0	11.24	37	0	0	7.34
5 by 5	0	0	0.83	69	0	0	11.4	38	0	0	7.54
6	0	0	0.99	70	0	0	11.57	39	0	0	7.74
7	0	0	1.16	71	0	0	11.74	40	0	0	7.93
8	0	0	1.32	72	0	0	11.9	41	0	0	8.13
9	0	0	1.49	73	0	0	12.07	42	0	0	8.33
10	0	0	1.65	74	0	0	12.23	43	0	0	8.53
11	0	0	1.82	75	0	0	12.4	44	0	0	8.73
12	0	0	1.98	76	0	0	12.56	45	0	0	8.93
13	0	0	2.15	77	0	0	12.73	46	0	0	9.12
14	0	0	2.31	78	0	0	12.89	47	0	0	9.32
15	0	0	2.48	79	0	0	13.06	48	0	0	9.52
16	0	0	2.64	80	0	0	13.22	49	0	0	9.72
17	0	0	2.81	81	0	0	13.39	50	0	0	9.92
18	0	0	2.98	82	0	0	13.55	51	0	0	10.12
19	0	0	3.14	83	0	0	13.72	52	0	0	10.31
20	0	0	3.31	84	0	0	13.88	53	0	0	10.51
21	0	0	3.47	85	0	0	14.05	54	0	0	10.71
22	0	0	3.64	86	0	0	14.21	55	0	0	10.91
23	0	0	3.8	87	0	0	14.38	56	0	0	11.11
24	0	0	3.97	88	0	0	14.55	57	0	0	11.31
25	0	0	4.13	89	0	0	14.71	58	0	0	11.5
26	0	0	4.3	90	0	0	14.88	59	0	0	11.7
27	0	0	4.46	91	0	0	15.04	60	0	0	11.9
28	0	0	4.63	92	0	0	15.21	61	0	0	12.1
29	0	0	4.79	93	0	0	15.37	62	0	0	12.3
30	0	0	4.96	94	0	0	15.54	63	0	0	12.5
31	0	0	5.12	95	0	0	15.7	64	0	0	12.69
32	0	0	5.29	96	0	0	15.87	65	0	0	12.89
33	0	0	5.45	97	0	0	16.03	66	0	0	13.09
34	0	0	5.62	98	0	0	16.2	67	0	0	13.29
35	0	0	5.79	99	0	0	16.36	68	0	0	13.49
36	0	0	5.95	100	0	0	16.53	69	0	0	13.69
37	0	0	6.12	6 by 6	0	0	1.19	70	0	0	13.88
38	0	0	6.28	7	0	0	1.39	71	0	0	14.08
39	0	0	6.45	8	0	0	1.59	72	0	0	14.28
40	0	0	6.61	9	0	0	1.79	73	0	0	14.48
41	0	0	6.78	10	0	0	1.98	74	0	0	14.68
42	0	0	6.94	11	0	0	2.18	75	0	0	14.88
43	0	0	7.11	12	0	0	2.38	76	0	0	15.07
44	0	0	7.27	13	0	0	2.58	77	0	0	15.27
45	0	0	7,44	14	0	0	2.78	78	0	0	15.47
46	0	0	7.6	15	0	0	2.98	79	0	0	15.67
47	0	0	7.77	16	0	0	3.17	80	0	0	15.87
48	0	0	7.93	17	0	0	3.37	81	0	0	16.07
49	0	0	8.10	18	0	0	3.57	82	0	0	16.26
50	0	0	8.26	19	0	0	3.77	83	0	0	16.46
51	0	0	8.43	20	0	0	3.97	84	0	0	16.66
52	0	0	8.6	21	0	0	4.17	85	0	0	16.86
53	0	0	8.76	22	0	0	4.36	86	0	0	17.06
54	0	0	8.93	23	0	0	4.56	87	0	0	17.26
55	0	0	9.09	24	0	0	4.76	88	0	0	17.45
56	0	0	9.26	25	0	0	4.96	89	0	0	17.65
57	0	0	9.42	26	0	0	5.16	90	0	0	17.85
58	0	0	9.59	27	0	0	5.36	91	0	0	18.05

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
6 by 92	0	0	18.25	7 by 62	0	0	14.35	8 by 33	0	0	8.73
93	0	0	18.45	63	0	0	14.58	34	0	0	8.99
94	0	0	18.64	64	0	0	14.81	35	0	0	9.26
95	0	0	18.84	65	0	0	15.04	36	0	0	9.52
96	0	0	19.04	66	0	0	15.27	37	0	0	9.79
97	0	0	19.24	67	0	0	15.5	38	0	0	10.05
98	0	0	19.44	68	0	0	15.74	39	0	0	10.31
99	0	0	19.64	69	0	0	15.97	40	0	0	10.58
100	0	0	19.83	70	0	0	16.2	41	0	0	10.84
7 by 7	0	0	1.62	71	0	0	16.43	42	0	0	11.11
8	0	0	1.85	72	0	0	16.66	43	0	0	11.37
9	0	0	2.08	73	0	0	16.89	44	0	0	11.64
10	0	0	2.31	74	0	0	17.12	45	0	0	11.9
11	0	0	2.55	75	0	0	17.36	46	0	0	12.17
12	0	0	2.78	76	0	0	17.59	47	0	0	12.43
13	0	0	3.01	77	0	0	17.82	48	0	0	12.69
14	0	0	3.24	78	0	0	18.05	49	0	0	12.96
15	0	0	3.47	79	0	0	18.28	50	0	0	13.22
16	0	0	3.7	80	0	0	18.51	51	0	0	13.49
17	0	0	3.93	81	0	0	18.74	52	0	0	13.75
18	0	0	4.17	82	0	0	18.98	53	0	0	14.02
19	0	0	4.4	83	0	0	19.21	54	0	0	14.28
20	0	0	4.63	84	0	0	19.44	55	0	0	14.55
21	0	0	4.86	85	0	0	19.67	56	0	0	14.81
22	0	0	5.09	86	0	0	19.9	57	0	0	15.07
23	0	0	5.32	87	0	0	20.13	58	0	0	15.34
24	0	0	5.55	88	0	0	20.36	59	0	0	15.6
25	0	0	5.79	89	0	0	20.6	60	0	0	15.87
26	0	0	6.02	90	0	0	20.83	61	0	0	16.13
27	0	0	6.25	91	0	0	21.06	62	0	0	16.4
28	0	0	6.48	92	0	0	21.29	63	0	0	16.66
29	0	0	6.71	93	0	0	21.52	64	0	0	16.93
30	0	0	6.94	94	0	0	21.75	65	0	0	17.19
31	0	0	7.17	95	0	0	21.98	66	0	0	17.45
32	0	0	7.4	96	0	0	22.21	67	0	0	17.72
33	0	0	7.64	97	0	0	22.45	68	0	0	17.98
34	0	0	7.87	98	0	0	22.68	69	0	0	18.25
35	0	0	8.1	99	0	0	22.91	70	0	0	18.51
36	0	0	8.33	100	0	0	23.14	71	0	0	18.78
37	0	0	8.56	8 by 8	0	0	2.12	72	0	0	19.04
38	0	0	8.79	9	0	0	2.38	73	0	0	19.31
39	0	0	9.02	10	0	0	2.64	74	0	0	19.57
40	0	0	9.26	11	0	0	2.91	75	0	0	19.83
41	0	0	9.49	12	0	0	3.17	76	0	0	20.1
42	0	0	9.72	13	0	0	3.44	77	0	0	20.36
43	0	0	9.95	14	0	0	3.7	78	0	0	20.63
44	0	0	10.18	15	0	0	3.97	79	0	0	20.89
45	0	0	10.41	16	0	0	4.23	80	0	0	21.16
46	0	0	10.64	17	0	0	4.5	81	0	0	21.42
47	0	0	10.88	18	0	0	4.76	82	0	0	21.69
48	0	0	11.11	19	0	0	5.02	83	0	0	21.95
49	0	0	11.34	20	0	0	5.29	84	0	0	22.21
50	0	0	11.57	21	0	0	5.55	85	0	0	22.48
51	0	0	11.8	22	0	0	5.82	86	0	0	22.74
52	0	0	12.03	23	0	0	6.08	87	0	0	23.01
53	0	0	12.26	24	0	0	6.35	88	0	0	23.27
54	0	0	12.5	25	0	0	6.61	89	0	0	23.54
55	0	0	12.73	26	0	0	6.88	90	0	0	23.8
56	0	0	12.96	27	0	0	7.14	91	0	0	24.07
57	0	0	13.19	28	0	0	7.4	92	0	0	24.33
58	0	0	13.42	29	0	0	7.67	93	0	0	24.6
59	0	0	13.65	30	0	0	7.93	94	0	0	24.86
60	0	0	13.88	31	0	0	8.20	95	0	0	25.12
61	0	0	14.12	32	0	0	8.46	96	0	0	25.39

Dimensions.	Statute content.	Dimensions.	Statute content.	Dimensions.	Statute content.
Yards.	A. R. P.	Yards.	A. R. P.	Yards.	A. R. P.
8 by 97	0 0 25.65	9 by 69	0 0 20.53	10 by 42	0 0 13.88
98	0 0 25.92	70	0 0 20.83	43	0 0 14.21
99	0 0 26.18	71	0 0 21.12	44	0 0 14.55
100	0 0 26.45	72	0 0 21.42	45	0 0 14.88
9 by 9	0 0 2.68	73	0 0 21.72	46	0 0 15.21
10	0 0 2.98	74	0 0 22.02	47	0 0 15.54
11	0 0 3.27	75	0 0 22.31	48	0 0 15.87
12	0 0 3.57	76	0 0 22.61	49	0 0 16.2
13	0 0 3.87	77	0 0 22.91	50	0 0 16.53
14	0 0 4.17	78	0 0 23.21	51	0 0 16.86
15	0 0 4.46	79	0 0 23.5	52	0 0 17.19
16	0 0 4.76	80	0 0 23.8	53	0 0 17.52
17	0 0 5.06	81	0 0 24.1	54	0 0 17.85
18	0 0 5.36	82	0 0 24.4	55	0 0 18.18
19	0 0 5.65	83	0 0 24.69	56	0 0 18.51
20	0 0 5.95	84	0 0 24.99	57	0 0 18.84
21	0 0 6.25	85	0 0 25.29	58	0 0 19.17
22	0 0 6.55	86	0 0 25.59	59	0 0 19.5
23	0 0 6.84	87	0 0 25.88	60	0 0 19.83
24	0 0 7.14	88	0 0 26.18	61	0 0 20.17
25	0 0 7.44	89	0 0 26.48	62	0 0 20.5
26	0 0 7.74	90	0 0 26.78	63	0 0 20.83
27	0 0 8.03	91	0 0 27.07	64	0 0 21.16
28	0 0 8.33	92	0 0 27.37	65	0 0 21.49
29	0 0 8.63	93	0 0 27.67	66	0 0 21.82
30	0 0 8.93	94	0 0 27.97	67	0 0 22.15
31	0 0 9.22	95	0 0 28.26	68	0 0 22.48
32	0 0 9.52	96	0 0 28.56	69	0 0 22.81
33	0 0 9.82	97	0 0 28.86	70	0 0 23.14
34	0 0 10.12	98	0 0 29.16	71	0 0 23.47
35	0 0 10.41	99	0 0 29.45	72	0 0 23.8
36	0 0 10.71	100	0 0 29.75	73	0 0 24.13
37	0 0 11.01	10 by 10	0 0 3.31	74	0 0 24.46
38	0 0 11.31	11	0 0 3.64	75	0 0 24.79
39	0 0 11.6	12	0 0 3.97	76	0 0 25.12
40	0 0 11.9	13	0 0 4.3	77	0 0 25.45
41	0 0 12.2	14	0 0 4.63	78	0 0 25.79
42	0 0 12.5	15	0 0 4.96	79	0 0 26.12
43	0 0 12.79	16	0 0 5.29	80	0 0 26.45
44	0 0 13.09	17	0 0 5.62	81	0 0 26.78
45	0 0 13.39	18	0 0 5.95	82	0 0 27.11
46	0 0 13.69	19	0 0 6.28	83	0 0 27.44
47	0 0 13.98	20	0 0 6.61	84	0 0 27.77
48	0 0 14.28	21	0 0 6.94	85	0 0 28.1
49	0 0 14.58	22	0 0 7.27	86	0 0 28.43
50	0 0 14.88	23	0 0 7.6	87	0 0 28.76
51	0 0 15.17	24	0 0 7.93	88	0 0 29.09
52	0 0 15.47	25	0 0 8.26	89	0 0 29.42
53	0 0 15.77	26	0 0 8.6	90	0 0 29.75
54	0 0 16.07	27	0 0 8.93	91	0 0 30.08
55	0 0 16.36	28	0 0 9.26	92	0 0 30.41
56	0 0 16.66	29	0 0 9.59	93	0 0 30.74
57	0 0 16.96	30	0 0 9.92	94	0 0 31.07
58	0 0 17.26	31	0 0 10.25	95	0 0 31.4
59	0 0 17.55	32	0 0 10.58	96	0 0 31.74
60	0 0 17.85	33	0 0 10.91	97	0 0 32.07
61	0 0 18.15	34	0 0 11.24	98	0 0 32.4
62	0 0 18.45	35	0 0 11.57	99	0 0 32.73
63	0 0 18.74	36	0 0 11.9	100	0 0 33.06
64	0 0 19.04	37	0 0 12.23	11 by 11	0 0 4.
65	0 0 19.34	38	0 0 12.56	12	0 0 4.36
66	0 0 19.64	39	0 0 12.89	13	0 0 4.73
67	0 0 19.93	40	0 0 13.22	14	0 0 5.09
68	0 0 20.23	41	0 0 13.55	15	0 0 5.45

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
11 by 16	0	0	5.82	11 by 80	0	0	29.19	12 by 55	0	0	21.82
17	0	0	6.18	81	0	0	29.56	56	0	0	22.21
18	0	0	6.55	82	0	0	29.92	57	0	0	22.61
19	0	0	6.91	83	0	0	30.28	58	0	0	23.01
20	0	0	7.27	84	0	0	30.65	59	0	0	23.4
21	0	0	7.64	85	0	0	31.01	60	0	0	23.8
22	0	0	8.	86	0	0	31.37	61	0	0	24.2
23	0	0	8.36	87	0	0	31.74	62	0	0	24.6
24	0	0	8.73	88	0	0	32.1	63	0	0	24.99
25	0	0	9.19	89	0	0	32.46	64	0	0	25.39
26	0	0	9.56	90	0	0	32.83	65	0	0	25.79
27	0	0	9.92	91	0	0	33.19	66	0	0	26.18
28	0	0	10.28	92	0	0	33.56	67	0	0	26.58
29	0	0	10.65	93	0	0	33.92	68	0	0	26.98
30	0	0	11.01	94	0	0	34.28	69	0	0	27.37
31	0	0	11.37	95	0	0	34.65	70	0	0	27.77
32	0	0	11.74	96	0	0	35.01	71	0	0	28.17
33	0	0	12.1	97	0	0	35.37	72	0	0	28.56
34	0	0	12.46	98	0	0	35.74	73	0	0	28.96
35	0	0	12.83	99	0	0	36.1	74	0	0	29.36
36	0	0	13.19	100	0	0	36.46	75	0	0	29.75
37	0	0	13.56	12 by 12	0	0	4.76	76	0	0	30.15
38	0	0	13.92	13	0	0	5.16	77	0	0	30.55
39	0	0	14.28	14	0	0	5.55	78	0	0	30.94
40	0	0	14.65	15	0	0	5.95	79	0	0	31.34
41	0	0	15.01	16	0	0	6.35	80	0	0	31.74
42	0	0	15.37	17	0	0	6.74	81	0	0	32.13
43	0	0	15.74	18	0	0	7.14	82	0	0	32.53
44	0	0	16.1	19	0	0	7.54	83	0	0	32.93
45	0	0	16.46	20	0	0	7.93	84	0	0	33.32
46	0	0	16.83	21	0	0	8.33	85	0	0	33.72
47	0	0	17.19	22	0	0	8.73	86	0	0	34.12
48	0	0	17.56	23	0	0	9.12	87	0	0	34.51
49	0	0	17.92	24	0	0	9.52	88	0	0	34.91
50	0	0	18.28	25	0	0	9.92	89	0	0	35.31
51	0	0	18.65	26	0	0	10.31	90	0	0	35.7
52	0	0	19.01	27	0	0	10.71	91	0	0	36.1
53	0	0	19.37	28	0	0	11.11	92	0	0	36.5
54	0	0	19.74	29	0	0	11.5	93	0	0	36.89
55	0	0	20.1	30	0	0	11.9	94	0	0	37.29
56	0	0	20.46	31	0	0	12.3	95	0	0	37.69
57	0	0	20.83	32	0	0	12.69	96	0	0	38.08
58	0	0	21.19	33	0	0	13.09	97	0	0	38.48
59	0	0	21.56	34	0	0	13.49	98	0	0	38.88
60	0	0	21.92	35	0	0	13.88	99	0	0	39.27
61	0	0	22.28	36	0	0	14.28	100	0	0	39.67
62	0	0	22.65	37	0	0	14.68	13 by 13	0	0	5.59
63	0	0	23.01	38	0	0	15.07	14	0	0	6.02
64	0	0	23.37	39	0	0	15.47	15	0	0	6.45
65	0	0	23.74	40	0	0	15.87	16	0	0	6.88
66	0	0	24.1	41	0	0	16.26	17	0	0	7.31
67	0	0	24.46	42	0	0	16.66	18	0	0	7.73
68	0	0	24.83	43	0	0	17.06	19	0	0	8.17
69	0	0	25.19	44	0	0	17.45	20	0	0	8.6
70	0	0	25.56	45	0	0	17.85	21	0	0	9.02
71	0	0	25.92	46	0	0	18.25	22	0	0	9.45
72	0	0	26.28	47	0	0	18.64	23	0	0	9.88
73	0	0	26.65	48	0	0	19.04	24	0	0	10.31
74	0	0	27.01	49	0	0	19.44	25	0	0	10.74
75	0	0	27.37	50	0	0	19.83	26	0	0	11.17
76	0	0	27.74	51	0	0	20.23	27	0	0	11.6
77	0	0	28.1	52	0	0	20.63	28	0	0	12.03
78	0	0	28.46	53	0	0	21.02	29	0	0	12.46
79	0	0	28.83	54	0	0	21.42	30	0	0	12.89

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
13 by 31	0	0	13.32	13 by 95	0	1	0.83	14 by 72	0	0	33.32
32	0	0	13.75	96	0	1	1.26	73	0	0	33.79
33	0	0	14.18	97	0	1	1.69	74	0	0	34.25
34	0	0	14.61	98	0	1	2.12	75	0	0	34.71
35	0	0	15.04	99	0	1	2.55	76	0	0	35.17
36	0	0	15.47	100	0	1	2.98	77	0	0	35.64
37	0	0	15.9	14 by 14	0	0	6.48	78	0	0	36.1
38	0	0	16.33	15	0	0	6.94	79	0	0	36.56
39	0	0	16.76	16	0	0	7.4	80	0	0	37.02
40	0	0	17.19	17	0	0	7.87	81	0	0	37.49
41	0	0	17.62	18	0	0	8.33	82	0	0	37.95
42	0	0	18.05	19	0	0	8.79	83	0	0	38.41
43	0	0	18.48	20	0	0	9.26	84	0	0	38.88
44	0	0	18.91	21	0	0	9.72	85	0	0	39.34
45	0	0	19.34	22	0	0	10.18	86	0	0	39.8
46	0	0	19.77	23	0	0	10.64	87	0	1	0.26
47	0	0	20.2	24	0	0	11.11	88	0	1	0.73
48	0	0	20.63	25	0	0	11.57	89	0	1	1.19
49	0	0	21.06	26	0	0	12.03	90	0	1	1.65
50	0	0	21.49	27	0	0	12.5	91	0	1	2.12
51	0	0	21.92	28	0	0	12.96	92	0	1	2.58
52	0	0	22.35	29	0	0	13.42	93	0	1	3.04
53	0	0	22.78	30	0	0	13.88	94	0	1	3.5
54	0	0	23.21	31	0	0	14.35	95	0	1	3.97
55	0	0	23.64	32	0	0	14.81	96	0	1	4.43
56	0	0	24.07	33	0	0	15.27	97	0	1	4.89
57	0	0	24.5	34	0	0	15.74	98	0	1	5.36
58	0	0	24.93	35	0	0	16.2	99	0	1	5.82
59	0	0	25.36	36	0	0	16.66	100	0	1	6.28
60	0	0	25.79	37	0	0	17.12	15 by 15	0	0	7.44
61	0	0	26.21	38	0	0	17.59	16	0	0	7.93
62	0	0	26.64	39	0	0	18.05	17	0	0	8.43
63	0	0	27.07	40	0	0	18.51	18	0	0	8.93
64	0	0	27.5	41	0	0	18.98	19	0	0	9.42
65	0	0	27.93	42	0	0	19.44	20	0	0	9.92
66	0	0	28.36	43	0	0	19.9	21	0	0	10.41
67	0	0	28.79	44	0	0	20.36	22	0	0	10.91
68	0	0	29.22	45	0	0	20.83	23	0	0	11.4
69	0	0	29.65	46	0	0	21.29	24	0	0	11.9
70	0	0	30.08	47	0	0	21.75	25	0	0	12.4
71	0	0	30.51	48	0	0	22.21	26	0	0	12.89
72	0	0	30.94	49	0	0	22.68	27	0	0	13.39
73	0	0	31.37	50	0	0	23.14	28	0	0	13.88
74	0	0	31.8	51	0	0	23.6	29	0	0	14.38
75	0	0	32.23	52	0	0	24.07	30	0	0	14.88
76	0	0	32.66	53	0	0	24.53	31	0	0	15.37
77	0	0	33.09	54	0	0	24.99	32	0	0	15.87
78	0	0	33.52	55	0	0	25.45	33	0	0	16.36
79	0	0	33.95	56	0	0	25.92	34	0	0	16.86
80	0	0	34.38	57	0	0	26.38	35	0	0	17.36
81	0	0	34.81	58	0	0	26.84	36	0	0	17.85
82	0	0	35.24	59	0	0	27.31	37	0	0	18.35
83	0	0	35.67	60	0	0	27.77	38	0	0	18.84
84	0	0	36.1	61	0	0	28.23	39	0	0	19.34
85	0	0	36.53	62	0	0	28.69	40	0	0	19.33
86	0	0	36.96	63	0	0	29.16	41	0	0	20.33
87	0	0	37.39	64	0	0	29.62	42	0	0	20.83
88	0	0	37.82	65	0	0	30.08	43	0	0	21.32
89	0	0	38.25	66	0	0	30.55	44	0	0	21.82
90	0	0	38.68	67	0	0	31.01	45	0	0	22.31
91	0	0	39.11	68	0	0	31.47	46	0	0	22.81
92	0	0	39.54	69	0	0	31.93	47	0	0	23.31
93	0	0	39.97	70	0	0	32.4	48	0	0	23.8
94	0	1	0.4	71	0	0	32.86	49	0	0	24.3

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
15 by 50	0	0	24.79	16 by 29	0	0	15.34	16 by 93	0	1	9.19
51	0	0	25.29	30	0	0	15.87	94	0	1	9.72
52	0	0	25.79	31	0	0	16.4	95	0	1	10.25
53	0	0	26.28	32	0	0	16.93	96	0	1	10.78
54	0	0	26.78	33	0	0	17.45	97	0	1	11.31
55	0	0	27.27	34	0	0	17.98	98	0	1	11.83
56	0	0	27.77	35	0	0	18.51	99	0	1	12.36
57	0	0	28.26	36	0	0	19.04	100	0	1	12.89
58	0	0	28.76	37	0	0	19.57	17 by 17	0	0	9.55
59	0	0	29.26	38	0	0	20.1	18	0	0	10.12
60	0	0	29.75	39	0	0	20.63	19	0	0	10.68
61	0	0	30.25	40	0	0	21.16	20	0	0	11.24
62	0	0	30.74	41	0	0	21.69	21	0	0	11.8
63	0	0	31.24	42	0	0	22.21	22	0	0	12.36
64	0	0	31.74	43	0	0	22.74	23	0	0	12.93
65	0	0	32.23	44	0	0	23.27	24	0	0	13.49
66	0	0	32.73	45	0	0	23.8	25	0	0	14.05
67	0	0	33.22	46	0	0	24.33	26	0	0	14.61
68	0	0	33.72	47	0	0	24.86	27	0	0	15.17
69	0	0	34.21	48	0	0	25.39	28	0	0	15.74
70	0	0	34.71	49	0	0	25.92	29	0	0	16.3
71	0	0	35.21	50	0	0	26.45	30	0	0	16.86
72	0	0	35.7	51	0	0	26.98	31	0	0	17.42
73	0	0	36.2	52	0	0	27.5	32	0	0	17.98
74	0	0	36.69	53	0	0	28.03	33	0	0	18.55
75	0	0	37.19	54	0	0	28.56	34	0	0	19.11
76	0	0	37.69	55	0	0	29.09	35	0	0	19.67
77	0	0	38.18	56	0	0	29.62	36	0	0	20.23
78	0	0	38.68	57	0	0	30.15	37	0	0	20.79
79	0	0	39.17	58	0	0	30.68	38	0	0	21.36
80	0	0	39.67	59	0	0	31.21	39	0	0	21.92
81	0	1	0.17	60	0	0	31.74	40	0	0	22.48
82	0	1	0.66	61	0	0	32.26	41	0	0	23.04
83	0	1	1.16	62	0	0	32.79	42	0	0	23.6
84	0	1	1.65	63	0	0	33.32	43	0	0	24.17
85	0	1	2.15	64	0	0	33.85	44	0	0	24.73
86	0	1	2.64	65	0	0	34.38	45	0	0	25.29
87	0	1	3.14	66	0	0	34.91	46	0	0	25.85
88	0	1	3.64	67	0	0	35.44	47	0	0	26.41
89	0	1	4.13	68	0	0	35.97	48	0	0	26.98
90	0	1	4.63	69	0	0	36.5	49	0	0	27.54
91	0	1	5.12	70	0	0	37.02	50	0	0	28.1
92	0	1	5.62	71	0	0	37.55	51	0	0	28.66
93	0	1	6.12	72	0	0	38.08	52	0	0	29.22
94	0	1	6.61	73	0	0	38.61	53	0	0	29.79
95	0	1	7.11	74	0	0	39.14	54	0	0	30.35
96	0	1	7.6	75	0	0	39.67	55	0	0	30.91
97	0	1	8.1	76	0	1	0.2	56	0	0	31.47
98	0	1	8.6	77	0	1	0.73	57	0	0	32.03
99	0	1	9.09	78	0	1	1.26	58	0	0	32.6
100	0	1	9.59	79	0	1	1.79	59	0	0	33.16
16 by 16	0	0	8.46	80	0	1	2.31	60	0	0	33.72
17	0	0	8.99	81	0	1	2.84	61	0	0	34.28
18	0	0	9.52	82	0	1	3.37	62	0	0	34.84
19	0	0	10.05	83	0	1	3.9	63	0	0	35.4
20	0	0	10.58	84	0	1	4.43	64	0	0	35.97
21	0	0	11.11	85	0	1	4.96	65	0	0	36.53
22	0	0	11.64	86	0	1	5.49	66	0	0	37.09
23	0	0	12.17	87	0	1	6.02	67	0	0	37.65
24	0	0	12.69	88	0	1	6.55	68	0	0	38.21
25	0	0	13.22	89	0	1	7.07	69	0	0	38.78
26	0	0	13.75	90	0	1	7.6	70	0	0	39.34
27	0	0	14.28	91	0	1	8.13	71	0	0	39.9
28	0	0	14.81	92	0	1	8.66	72	0	1	0.46

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
17 by 73	0	1	1.02	18 by 54	0	0	32.13	19 by 36	0	0	22.61
74	0	1	1.59	55	0	0	32.73	37	0	0	23.24
75	0	1	2.15	56	0	0	33.32	38	0	0	23.87
76	0	1	2.71	57	0	0	33.92	39	0	0	24.5
77	0	1	3.27	58	0	0	34.51	40	0	0	25.12
78	0	1	3.83	59	0	0	35.11	41	0	0	25.75
79	0	1	4.4	60	0	0	35.7	42	0	0	26.38
80	0	1	4.96	61	0	0	36.3	43	0	0	27.01
81	0	1	5.52	62	0	0	36.89	44	0	0	27.64
82	0	1	6.08	63	0	0	37.49	45	0	0	28.26
83	0	1	6.64	64	0	0	38.08	46	0	0	28.89
84	0	1	7.21	65	0	0	38.68	47	0	0	29.52
85	0	1	7.77	66	0	0	39.27	48	0	0	30.15
86	0	1	8.33	67	0	0	39.87	49	0	0	30.78
87	0	1	8.89	68	0	1	0.46	50	0	0	31.4
88	0	1	9.45	69	0	1	1.06	51	0	0	32.03
89	0	1	10.02	70	0	1	1.65	52	0	0	32.66
90	0	1	10.58	71	0	1	2.25	53	0	0	33.29
91	0	1	11.14	72	0	1	2.84	54	0	0	33.92
92	0	1	11.7	73	0	1	3.44	55	0	0	34.55
93	0	1	12.26	74	0	1	4.03	56	0	0	35.17
94	0	1	12.83	75	0	1	4·63	57	0	0	35.8
95	0	1	13.39	76	0	1	5.22	58	0	0	36.43
96	0	1	13.95	77	0	1	5.82	59	0	0	37.06
97	0	1	14.51	78	0	1	6.41	60	0	0	37.69
98	0	1	15.07	79	0	1	7.01	61	0	0	38.31
99	0	1	15.64	80	0	1	7.6	62	0	0	38.94
100	0	1	16.2	81	0	1	8.2	63	0	0	39.57
18 by 18	0	0	10.71	82	0	1	8·79	64	0	1	0.2
19	0	0	11.31	83	0	1	9.39	65	0	1	0.83
20	0	0	11.9	84	0	1	9.98	66	0	1	1.45
21	0	0	12.5	85	0	1	10.58	67	0	1	2.08
22	0	0	13.09	86	0	1	11.17	68	0	1	2.71
23	0	0	13.69	87	0	1	11.77	69	0	1	3.34
24	0	0	14.28	88	0	1	12.36	70	0	1	3.97
25	0	0	14.88	89	0	1	12.96	71	0	1	4.6
26	0	0	15.47	90	0	1	13.55	72	0	1	5.22
27	0	0	16.07	91	0	1	14.15	73	0	1	5.85
28	0	0	16.66	92	0	1	14.74	74	0	1	6.48
29	0	0	17.26	93	0	1	15.34	75	0	1	7.11
30	0	0	17.85	94	0	1	15.93	76	0	1	7.74
31	0	0	18.45	95	0	1	16.53	77	0	1	8.36
32	0	0	19.04	96	0	1	17.12	78	0	1	8.99
33	0	0	19.64	97	0	1	17.72	79	0	1	9.62
34	0	0	20.23	98	0	1	18.31	80	0	1	10.25
35	0	0	20.83	99	0	1	18.91	81	0	1	10.88
36	0	0	21.42	100	0	1	19.5	82	0	1	11.5
37	0	0	22.02	19 by 19	0	0	11.93	83	0	1	12.13
38	0	0	22.61	20	0	0	12.56	84	0	1	12.76
39	0	0	23.21	21	0	0	13.19	85	0	1	13.39
40	0	0	23.8	22	0	0	13.82	86	0	1	14.02
41	0	0	24.4	23	0	0	14.45	87	0	1	14.64
42	0	0	24.99	24	0	0	15.07	88	0	1	15.27
43	0	0	25.59	25	0	0	15.7	89	0	1	15.9
44	0	0	26.18	26	0	0	16.33	90	0	1	16.53
45	0	0	26.78	27	0	0	16.96	91	0	1	17.16
46	0	0	27.37	28	0	0	17.59	92	0	1	17.79
47	0	0	27.97	29	0	0	18.21	93	0	1	18.41
48	0	0	28.56	30	0	0	18.84	94	0	1	19.04
49	0	0	29.16	31	0	0	19.47	95	0	1	19.67
50	0	0	29.75	32	0	0	20.1	96	0	1	20.3
51	0	0	30.35	33	0	0	20.73	97	0	1	20.93
52	0	0	30.94	34	0	0	21.36	98	0	1	21.55
53	0	0	31.54	35	0	0	21.98	99	0	1	22.18

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
19 by 100	0	1	22.81	20 by 83	0	1	14.88	21 by 67	0	1	6.51
20 by 20	0	0	13.22	84	0	1	15.54	68	0	1	7.21
21	0	0	13.88	85	0	1	16.2	69	0	1	7.9
22	0	0	14.55	86	0	1	16.86	70	0	1	8.6
23	0	0	15.21	87	0	1	17.52	71	0	1	9.29
24	0	0	15.87	88	0	1	18.18	72	0	1	9.98
25	0	0	16.53	89	0	1	18.84	73	0	1	10.68
26	0	0	17.19	90	0	1	19.5	74	0	1	11.37
27	0	0	17.85	91	0	1	20.17	75	0	1	12.07
28	0	0	18.51	92	0	1	20.83	76	0	1	12.76
29	0	0	19.17	93	0	1	21.49	77	0	1	13.45
30	0	0	19.83	94	0	1	22.15	78	0	1	14.15
31	0	0	20.5	95	0	1	22.81	79	0	1	14.84
32	0	0	21.16	96	0	1	23.47	80	0	1	15.54
33	0	0	21.82	97	0	1	24.13	81	0	1	16.23
34	0	0	22.48	98	0	1	24.79	82	0	1	16.93
35	0	0	23.14	99	0	1	25.45	83	0	1	17.62
36	0	0	23.8	100	0	1	26.12	84	0	1	18.31
37	0	0	24.46	21 by 21	0	0	14.58	85	0	1	19.01
38	0	0	25.12	22	0	0	15.27	86	0	1	19.7
39	0	0	25.79	23	0	0	15.97	87	0	1	20.4
40	0	0	26.45	24	0	0	16.66	88	0	1	21.09
41	0	0	27.11	25	0	0	17.36	89	0	1	21.79
42	0	0	27.77	26	0	0	18.05	90	0	1	22.48
43	0	0	28.43	27	0	0	18.74	91	0	1	23.17
44	0	0	29.09	28	0	0	19.44	92	0	1	23.87
45	0	0	29.75	29	0	0	20.13	93	0	1	24.56
46	0	0	30.41	30	0	0	20.83	94	0	1	25.26
47	0	0	31.07	31	0	0	21.52	95	0	1	25.95
48	0	0	31.74	32	0	0	22.21	96	0	1	26.64
49	0	0	32.4	33	0	0	22.91	97	0	1	27.34
50	0	0	33.06	34	0	0	23.6	98	0	1	28.03
51	0	0	33.72	35	0	0	24.3	99	0	1	28.73
52	0	0	34.38	36	0	0	24.99	100	0	1	29.42
53	0	0	35.04	37	0	0	25.69	22 by 22	0	0	16.
54	0	0	35.7	38	0	0	26.38	23	0	0	16.73
55	0	0	36.36	39	0	0	27.07	24	0	0	17.45
56	0	0	37.02	40	0	0	27.77	25	0	0	18.18
57	0	0	37.69	41	0	0	28.46	26	0	0	18.91
58	0	0	38.35	42	0	0	29.16	27	0	0	19.64
59	0	0	39.01	43	0	0	29.85	28	0	0	20.36
60	0	0	39.67	44	0	0	30.55	29	0	0	21.09
61	0	1	0.33	45	0	0	31.24	30	0	0	21.82
62	0	1	0.99	46	0	0	31.93	31	0	0	22.55
63	0	1	1.65	47	0	0	32.63	32	0	0	23.27
64	0	1	2.31	48	0	0	33.32	33	0	0	24.
65	0	1	2.98	49	0	0	34.02	34	0	0	24.73
66	0	1	3.64	50	0	0	34.71	35	0	0	25.45
67	0	1	4.3	51	0	0	35.4	36	0	0	26.18
68	0	1	4.96	52	0	0	36.1	37	0	0	26.91
69	0	1	5.62	53	0	0	36.79	38	0	0	27.64
70	0	1	6.28	54	0	0	37.49	39	0	0	28.36
71	0	1	6.94	55	0	0	38.18	40	0	0	29.09
72	0	1	7.6	56	0	0	38.88	41	0	0	29.82
73	0	1	8.26	57	0	0	39.57	42	0	0	30.55
74	0	1	8.93	58	0	1	0.26	43	0	0	31.27
75	0	1	9.59	59	0	1	0.96	44	0	0	32.
76	0	1	10.25	60	0	1	1.65	45	0	0	32.73
77	0	1	10.91	61	0	1	2.35	46	0	0	33.45
78	0	1	11.57	62	0	1	3.04	47	0	0	34.18
79	0	1	12.23	63	0	1	3.74	48	0	0	34.91
80	0	1	12.89	64	0	1	4.43	49	0	0	35.64
81	0	1	13.55	65	0	1	5.12	50	0	0	36.36
82	0	1	14.21	66	0	1	5.82	51	0	0	37.09

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
22 by 52	0	0	37.82	23 by 38	0	0	28.89	24 by 25	0	0	19.83
53	0	0	38.55	39	0	0	29.65	26	0	0	20.63
54	0	0	39.27	40	0	0	30.41	27	0	0	21.42
55	0	1	0.	41	0	0	31.17	28	0	0	22.21
56	0	1	0.73	42	0	0	31.93	29	0	0	23.01
57	0	1	1.45	43	0	0	32.69	30	0	0	23.8
58	0	1	2.18	44	0	0	33.45	31	0	0	24.6
59	0	1	2.91	45	0	0	34.21	32	0	0	25.39
60	0	1	3.64	46	0	0	34.98	33	0	0	26.18
61	0	1	4.36	47	0	0	35.74	34	0	0	26.98
62	0	1	5.09	48	0	0	36.5	35	0	0	27.77
63	0	1	5.82	49	0	0	37.26	36	0	0	28.56
64	0	1	6.55	50	0	0	38.02	37	0	0	29.36
65	0	1	7.27	51	0	0	38.78	38	0	0	30.15
66	0	1	8.	52	0	0	39.54	39	0	0	30.94
67	0	1	8.73	53	0	1	0.3	40	0	0	31.74
68	0	1	9.45	54	0	1	1.06	41	0	0	32.53
69	0	1	10.18	55	0	1	1.82	42	0	0	33.32
70	0	1	10.91	56	0	1	2.58	43	0	0	34.12
71	0	1	11.64	57	0	1	3.34	44	0	0	34.91
72	0	1	12.36	58	0	1	4.1	45	0	0	35.7
73	0	1	13.09	59	0	1	4.86	46	0	0	36.5
74	0	1	13.82	60	0	1	5.62	47	0	0	37.29
75	0	1	14.55	61	0	1	6.38	48	0	0	38.08
76	0	1	15.27	62	0	1	7.14	49	0	0	38.88
77	0	1	16.	63	0	1	7.9	50	0	0	39.67
78	0	1	16.73	64	0	1	8.66	51	0	1	0.46
79	0	1	17.45	65	0	1	9.42	52	0	1	1.26
80	0	1	18.18	66	0	1	10.18	53	0	1	2.05
81	0	1	18.91	67	0	1	10.94	54	0	1	2.84
82	0	1	19.64	68	0	1	11.7	55	0	1	3.64
83	0	1	20.36	69	0	1	12.46	56	0	1	4.43
84	0	1	21.09	70	0	1	13.22	57	0	1	5.22
85	0	1	21.82	71	0	1	13.98	58	0	1	6.02
86	0	1	22.55	72	0	1	14.74	59	0	1	6.81
87	0	1	23.27	73	0	1	15.5	60	0	1	7.6
88	0	1	24.	74	0	1	16.26	61	0	1	8.4
89	0	1	24.73	75	0	1	17.02	62	0	1	9.19
90	0	1	25.45	76	0	1	17.79	63	0	1	9.98
91	0	1	26.18	77	0	1	18.55	64	0	1	10.78
92	0	1	26.91	78	0	1	19.31	65	0	1	11.57
93	0	1	27.64	79	0	1	20.07	66	0	1	12.36
94	0	1	28.36	80	0	1	20.83	67	0	1	13.16
95	0	1	29.09	81	0	1	21.59	68	0	1	13.95
96	0	1	29.82	82	0	1	22.35	69	0	1	14.74
97	0	1	30.55	83	0	1	23.11	70	0	1	15.54
98	0	1	31.27	84	0	1	23.87	71	0	1	16.33
99	0	1	32.	85	0	1	24.63	72	0	1	17.12
100	0	1	32.73	86	0	1	25.39	73	0	1	17.92
23 by 23	0	0	17.49	87	0	1	26.15	74	0	1	18.71
24	0	0	18.25	88	0	1	26.91	75	0	1	19.5
25	0	0	19.01	89	0	1	27.67	76	0	1	20.3
26	0	0	19.77	90	0	1	28.43	77	0	1	21.09
27	0	0	20.53	91	0	1	29.19	78	0	1	21.88
28	0	0	21.29	92	0	1	29.95	79	0	1	22.68
29	0	0	22.05	93	0	1	30.71	80	0	1	23.47
30	0	0	22.81	94	0	1	31.47	81	0	1	24.26
31	0	0	23.57	95	0	1	32.23	82	0	1	25.06
32	0	0	24.33	96	0	1	32.99	83	0	1	25.85
33	0	0	25.09	97	0	1	33.75	84	0	1	26.64
34	0	0	25.85	98	0	1	34.51	85	0	1	27.44
35	0	0	26.61	99	0	1	35.27	86	0	1	28.23
36	0	0	27.37	100	0	1	36.03	87	0	1	29.02
37	0	0	28.13	24 by 24	0	0	19.04	88	0	1	29.82

Dimensions.	Statute content.	Dimensions.	Statute content.	Dimensions.	Statute content.
Yards.	A. R. P.	Yards.	A. R. P.	Yards.	A. R. P.
24 by 89	0 1 30.61	**25** by 77	0 1 23.64	**26** by 66	0 1 16.73
90	0 1 31.4	78	0 1 24.46	67	0 1 17.59
91	0 1 32.2	79	0 1 25.29	68	0 1 18.45
92	0 1 32.99	80	0 1 26.12	69	0 1 19.31
93	0 1 33.79	81	0 1 26.94	70	0 1 20.17
94	0 1 34.58	82	0 1 27.77	71	0 1 21.02
95	0 1 35.37	83	0 1 28.6	72	0 1 21.88
96	0 1 36.17	84	0 1 29.42	73	0 1 22.74
97	0 1 36.96	85	0 1 30.25	74	0 1 23.6
98	0 1 37.75	86	0 1 31.07	75	0 1 24.46
99	0 1 38.55	87	0 1 31.9	76	0 1 25.32
100	0 1 39.34	88	0 1 32.73	77	0 1 26.18
25 by 25	0 0 20.66	89	0 1 33.55	78	0 1 27.04
26	0 0 21.49	90	0 1 34.38	79	0 1 27.9
27	0 0 22.31	91	0 1 35.21	80	0 1 28.76
28	0 0 23.14	92	0 1 36.03	81	0 1 29.62
29	0 0 23.97	93	0 1 36.86	82	0 1 30.48
30	0 0 24.79	94	0 1 37.69	83	0 1 31.34
31	0 0 25.62	95	0 1 38.51	84	0 1 32.2
32	0 0 26.45	96	0 1 39.34	85	0 1 33.06
33	0 0 27.27	97	0 2 0.17	86	0 1 33.92
34	0 0 28.1	98	0 2 0.99	87	0 1 34.78
35	0 0 28.93	99	0 2 1.82	88	0 1 35.64
36	0 0 29.75	100	0 2 2.64	89	0 1 36.5
37	0 0 30.58	**26** by 26	0 0 22.35	90	0 1 37.36
38	0 0 31.4	27	0 0 23.21	91	0 1 38.21
39	0 0 32.23	28	0 0 24.07	92	0 1 39.07
40	0 0 33.06	29	0 0 24.93	93	0 1 39.93
41	0 0 33.88	30	0 0 25.79	94	0 2 0.79
42	0 0 34.71	31	0 0 26.64	95	0 2 1.65
43	0 0 35.54	32	0 0 27.5	96	0 2 2.51
44	0 0 36.36	33	0 0 28.36	97	0 2 3.37
45	0 0 37.19	34	0 0 29.22	98	0 2 4.23
46	0 0 38.02	35	0 0 30.08	99	0 2 5.09
47	0 0 38.84	36	0 0 30.94	100	0 2 5.95
48	0 0 39.67	37	0 0 31.8	**27** by 27	0 0 24.1
49	0 1 0.5	38	0 0 32.66	28	0 0 24.99
50	0 1 1.32	39	0 0 33.52	29	0 0 25.88
51	0 1 2.15	40	0 0 34.38	30	0 0 26.78
52	0 1 2.98	41	0 0 35.24	31	0 0 27.67
53	0 1 3.8	42	0 0 36.1	32	0 0 28.56
54	0 1 4.63	43	0 0 36.96	33	0 0 29.45
55	0 1 5.45	44	0 0 37.82	34	0 0 30.35
56	0 1 6.28	45	0 0 38.68	35	0 0 31.24
57	0 1 7.11	46	0 0 39.54	36	0 0 32.13
58	0 1 7.93	47	0 1 0.4	37	0 0 33.02
59	0 1 8.76	48	0 1 1.26	38	0 0 33.92
60	0 1 9.59	49	0 1 2.12	39	0 0 34.81
61	0 1 10.41	50	0 1 2.98	40	0 0 35.7
62	0 1 11.24	51	0 1 3.83	41	0 0 36.6
63	0 1 12.07	52	0 1 4.69	42	0 0 37.49
64	0 1 12.89	53	0 1 5.55	43	0 0 38.38
65	0 1 13.72	54	0 1 6.41	44	0 0 39.27
66	0 1 14.55	55	0 1 7.27	45	0 1 0.17
67	0 1 15.37	56	0 1 8.13	46	0 1 1.06
68	0 1 16.2	57	0 1 8.99	47	0 1 1.95
69	0 1 17.02	58	0 1 9.85	48	0 1 2.84
70	0 1 17.85	59	0 1 10.71	49	0 1 3.74
71	0 1 18.68	60	0 1 11.57	50	0 1 4.63
72	0 1 19.5	61	0 1 12.43	51	0 1 5.52
73	0 1 20.33	62	0 1 13.29	52	0 1 6.41
74	0 1 21.16	63	0 1 14.15	53	0 1 7.31
75	0 1 21.98	64	0 1 15.01	54	0 1 8.2
76	0 1 22.81	65	0 1 15.87	55	0 1 9.09

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
27 by 56	0	1	9.98	28 by 47	0	1	3.5	29 by 39	0	0	37.39
57	0	1	10.88	48	0	1	4.43	40	0	0	38.35
58	0	1	11.77	49	0	1	5.36	41	0	0	39.31
59	0	1	12.66	50	0	1	6.28	42	0	1	0.26
60	0	1	13.55	51	0	1	7.21	43	0	1	1.22
61	0	1	14.45	52	0	1	8.13	44	0	1	2.18
62	0	1	15.34	53	0	1	9.06	45	0	1	3.14
63	0	1	16.23	54	0	1	9.98	46	0	1	4.1
64	0	1	17.12	55	0	1	10.91	47	0	1	5.06
65	0	1	18.02	56	0	1	11.83	48	0	1	6.02
66	0	1	18.91	57	0	1	12.76	49	0	1	7.98
67	0	1	19.8	58	0	1	13.69	50	0	1	8.93
68	0	1	20.69	59	0	1	14.61	51	0	1	9.89
69	0	1	21.59	60	0	1	15.54	52	0	1	10.85
70	0	1	22.48	61	0	1	16.46	53	0	1	11.81
71	0	1	23.37	62	0	1	17.39	54	0	1	12.77
72	0	1	24.26	63	0	1	18.31	55	0	1	13.73
73	0	1	25.16	64	0	1	19.24	56	0	1	14.69
74	0	1	26.05	65	0	1	20.17	57	0	1	15.64
75	0	1	26.94	66	0	1	21.09	58	0	1	16.6
76	0	1	27.83	67	0	1	22.02	59	0	1	17.56
77	0	1	28.73	68	0	1	22.94	60	0	1	18.52
78	0	1	29.62	69	0	1	23.87	61	0	1	19.48
79	0	1	30.51	70	0	1	24.79	62	0	1	20.44
80	0	1	31.4	71	0	1	25.72	63	0	1	21.4
81	0	1	32.3	72	0	1	26.64	64	0	1	22.36
82	0	1	33.19	73	0	1	27.57	65	0	1	23.31
83	0	1	34.08	74	0	1	28.5	66	0	1	24.27
84	0	1	34.98	75	0	1	29.42	67	0	1	25.23
85	0	1	35.87	76	0	1	30.35	68	0	1	26.19
86	0	1	36.76	77	0	1	31.27	69	0	1	27.15
87	0	1	37.65	78	0	1	32.2	70	0	1	28.11
88	0	1	38.55	79	0	1	33.12	71	0	1	29.07
89	0	1	39.44	80	0	1	34.05	72	0	1	30.02
90	0	2	0.33	81	0	1	34.98	73	0	1	30.98
91	0	2	1.22	82	0	1	35.9	74	0	1	31.94
92	0	2	2.12	83	0	1	36.83	75	0	1	32.9
93	0	2	3.01	84	0	1	37.75	76	0	1	33.86
94	0	2	4.9	85	0	1	38.68	77	0	1	34.82
95	0	2	4.79	86	0	1	39.6	78	0	1	35.78
96	0	2	5.69	87	0	2	0.53	79	0	1	36.74
97	0	2	6.58	88	0	2	1.45	80	0	1	37.69
98	0	2	7.47	89	0	2	2.38	81	0	1	38.65
99	0	2	8.36	90	0	2	3.31	82	0	1	39.61
100	0	2	9.26	91	0	2	4.23	83	0	2	0.57
28 by 28	0	0	25.92	92	0	2	5.16	84	0	2	1.53
29	0	0	26.84	93	0	2	6.08	85	0	2	2.49
30	0	0	27.77	94	0	2	7.01	86	0	2	3.45
31	0	0	28.69	95	0	2	7.93	87	0	2	4.4
32	0	0	29.62	96	0	2	8.86	88	0	2	5.36
33	0	0	30.55	97	0	2	9.79	89	0	2	6.32
34	0	0	31.47	98	0	2	10.71	90	0	2	7.28
35	0	0	32.4	99	0	2	11.64	91	0	2	8.24
36	0	0	33.32	100	0	2	12.56	92	0	2	9.2
37	0	0	34.25	29 by 29	0	0	27.8	93	0	2	10.16
38	0	0	35.17	30	0	0	28.76	94	0	2	11.12
39	0	0	36.1	31	0	0	29.72	95	0	2	12.07
40	0	0	37.02	32	0	0	30.68	96	0	2	13.03
41	0	0	37.95	33	0	0	31.64	97	0	2	13.99
42	0	0	38.88	34	0	0	32.6	98	0	2	14.95
43	0	0	39.8	35	0	0	33.55	99	0	2	15.91
44	0	1	0.73	36	0	0	34.51	100	0	2	16.87
45	0	1	1.65	37	0	0	35.47	30 by 30	0	0	29.75
46	0	1	2.58	38	0	0	36.43	31	0	0	30.74

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
30 by 32	0	0	31.74	96	0	2	15.21	31 by 90	0	2	12.23
33	0	0	32.73	97	0	2	16.2	91	0	2	13.26
34	0	0	33.72	98	0	2	17.19	92	0	2	14.28
35	0	0	34.71	99	0	2	18.18	93	0	2	15.31
36	0	0	35.7	100	0	2	19.17	94	0	2	16.33
37	0	0	36.69	31 by 31	0	0	31.77	95	0	2	17.36
38	0	0	37.69	32	0	0	32.79	96	0	2	18.38
39	0	0	38.68	33	0	0	33.82	97	0	2	19.4
40	0	0	39.67	34	0	0	34.84	98	0	2	20.43
41	0	1	0.66	35	0	0	35.87	99	0	2	21.45
42	0	1	1.65	36	0	0	36.89	100	0	2	22.48
43	0	1	2.64	37	0	0	37.92	32 by 32	0	0	33.85
44	0	1	3.64	38	0	0	38.94	33	0	0	34.91
45	0	1	4.63	39	0	0	39.97	34	0	0	35.97
46	0	1	5.62	40	0	1	0.99	35	0	0	37.02
47	0	1	6.61	41	0	1	2.02	36	0	0	38.08
48	0	1	7.6	42	0	1	3.04	37	0	0	39.14
49	0	1	8.6	43	0	1	4.07	38	0	1	0.2
50	0	1	9.59	44	0	1	5.09	39	0	1	1.26
51	0	1	10.58	45	0	1	6.12	40	0	1	2.31
52	0	1	11.57	46	0	1	7.14	41	0	1	3.37
53	0	1	12.56	47	0	1	8.17	42	0	1	4.43
54	0	1	13.55	48	0	1	9.19	43	0	1	5.49
55	0	1	14.55	49	0	1	10.21	44	0	1	6.55
56	0	1	15.54	50	0	1	11.24	45	0	1	7.6
57	0	1	16.53	51	0	1	12.26	46	0	1	8.66
58	0	1	17.52	52	0	1	13.29	47	0	1	9.72
59	0	1	18.51	53	0	1	14.31	48	0	1	10.78
60	0	1	19.5	54	0	1	15.34	49	0	1	11.83
61	0	1	20.5	55	0	1	16.36	50	0	1	12.89
62	0	1	21.49	56	0	1	17.39	51	0	1	13.95
63	0	1	22.48	57	0	1	18.41	52	0	1	15.01
64	0	1	23.47	58	0	1	19.44	53	0	1	16.07
65	0	1	24.46	59	0	1	20.46	54	0	1	17.12
66	0	1	25.45	60	0	1	21.49	55	0	1	18.18
67	0	1	26.45	61	0	1	22.51	56	0	1	19.24
68	0	1	27.44	62	0	1	23.54	57	0	1	20.3
69	0	1	28.43	63	0	1	24.56	58	0	1	21.36
70	0	1	29.42	64	0	1	25.59	59	0	1	22.41
71	0	1	30.41	65	0	1	26.61	60	0	1	23.47
72	0	1	31.4	66	0	1	27.64	61	0	1	24.53
73	0	1	32.4	67	0	1	28.66	62	0	1	25.59
74	0	1	33.39	68	0	1	29.69	63	0	1	26.64
75	0	1	34.38	69	0	1	30.71	64	0	1	27.7
76	0	1	35.37	70	0	1	31.74	65	0	1	28.76
77	0	1	36.36	71	0	1	32.76	66	0	1	29.82
78	0	1	37.36	72	0	1	33.79	67	0	1	30.88
79	0	1	38.35	73	0	1	34.81	68	0	1	31.93
80	0	1	39.34	74	0	1	35.83	69	0	1	32.99
81	0	2	0.33	75	0	1	36.86	70	0	1	34.05
82	0	2	1.32	76	0	1	37.88	71	0	1	35.11
83	0	2	2.31	77	0	1	38.91	72	0	1	36.17
84	0	2	3.31	78	0	1	39.93	73	0	1	37.22
85	0	2	4.3	79	0	2	0.96	74	0	1	38.28
86	0	2	5.29	80	0	2	1.98	75	0	1	39.34
87	0	2	6.28	81	0	2	3.01	76	0	2	0.4
88	0	2	7.27	82	0	2	4.03	77	0	2	1.45
89	0	2	8.26	83	0	2	5.06	78	0	2	2.51
90	0	2	9.26	84	0	2	6.08	79	0	2	3.57
91	0	2	10.25	85	0	2	7.11	80	0	2	4.63
92	0	2	11.24	86	0	2	8.13	81	0	2	5.69
93	0	2	12.23	87	0	2	9.16	82	0	2	6.74
94	0	2	13.22	88	0	2	10.18	83	0	2	7.8
95	0	2	14.21	89	0	2	11.21	84	0	2	8.86

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
32 by 85	0	2	9.92	**33** by 81	0	2	8.36	**34** by 78	0	2	7.67
86	0	2	10.98	82	0	2	9.45	79	0	2	8.79
87	0	2	12.03	83	0	2	10.55	80	0	2	9.92
88	0	2	13.09	84	0	2	11.64	81	0	2	11.04
89	0	2	14.15	85	0	2	12.73	82	0	2	12.17
90	0	2	15.21	86	0	2	13.82	83	0	2	13.29
91	0	2	16.26	87	0	2	14.91	84	0	2	14.41
92	0	2	17.32	88	0	2	16.	85	0	2	15.54
93	0	2	18.38	89	0	2	17.09	86	0	2	16.66
94	0	2	19.44	90	0	2	18.18	87	0	2	17.79
95	0	2	20.5	91	0	2	19.27	88	0	2	18.91
96	0	2	21.55	92	0	2	20.36	89	0	2	20.03
97	0	2	22.61	93	0	2	21.45	90	0	2	21.16
98	0	2	23.67	94	0	2	22.55	91	0	2	22.28
99	0	2	24.73	95	0	2	23.64	92	0	2	23.4
100	0	2	25.79	96	0	2	24.73	93	0	2	24.53
33 by 33	0	0	36.	97	0	2	25.82	94	0	2	25.65
34	0	0	37.09	98	0	2	26.91	95	0	2	26.78
35	0	0	38.18	99	0	2	28.	96	0	2	27.9
36	0	0	39.27	100	0	2	29.09	97	0	2	29.02
37	0	1	0.36	**34** by 34	0	0	38.21	98	0	2	30.15
38	0	1	1.45	35	0	0	39.34	99	0	2	31.27
39	0	1	2.55	36	0	1	0.46	100	0	2	32.4
40	0	1	3.64	37	0	1	1.59	**35** by 35	0	1	0.5
41	0	1	4.73	38	0	1	2.71	36	0	1	1.65
42	0	1	5.82	39	0	1	3.83	37	0	1	2.81
43	0	1	6.91	40	0	1	4.96	38	0	1	3.97
44	0	1	8.	41	0	1	6.08	39	0	1	5.12
45	0	1	9.09	42	0	1	7.21	40	0	1	6.28
46	0	1	10.18	43	0	1	8.33	41	0	1	7.44
47	0	1	11.27	44	0	1	9.45	42	0	1	8.6
48	0	1	12.36	45	0	1	10.58	43	0	1	9.75
49	0	1	13.45	46	0	1	11.7	44	0	1	10.91
50	0	1	14.55	47	0	1	12.83	45	0	1	12.07
51	0	1	15.64	48	0	1	13.95	46	0	1	13.22
52	0	1	16.73	49	0	1	15.07	47	0	1	14.38
53	0	1	17.82	50	0	1	16.2	48	0	1	15.54
54	0	1	18.91	51	0	1	17.32	49	0	1	16.69
55	0	1	20.	52	0	1	18.45	50	0	1	17.85
56	0	1	21.09	53	0	1	19.57	51	0	1	19.01
57	0	1	22.18	54	0	1	20.69	52	0	1	20.17
58	0	1	23.27	55	0	1	21.82	53	0	1	21.32
59	0	1	24.36	56	0	1	22.94	54	0	1	22.48
60	0	1	25.45	57	0	1	24.07	55	0	1	23.64
61	0	1	26.55	58	0	1	25.19	56	0	1	24.79
62	0	1	27.64	59	0	1	26.31	57	0	1	25.95
63	0	1	28.73	60	0	1	27.44	58	0	1	27.11
64	0	1	29.82	61	0	1	28.56	59	0	1	28.26
65	0	1	30.91	62	0	1	29.69	60	0	1	29.42
66	0	1	32.	63	0	1	30.81	61	0	1	30.58
67	0	1	33.09	64	0	1	31.93	62	0	1	31.74
68	0	1	34.18	65	0	1	33.06	63	0	1	32.89
69	0	1	35.27	66	0	1	34.18	64	0	1	34.05
70	0	1	36.36	67	0	1	35.31	65	0	1	35.21
71	0	1	37.45	68	0	1	36.43	66	0	1	36.36
72	0	1	38.55	69	0	1	37.55	67	0	1	37.52
73	0	1	39.64	70	0	1	38.68	68	0	1	38.68
74	0	2	0.73	71	0	1	39.8	69	0	1	39.83
75	0	2	1.82	72	0	2	0.93	70	0	2	0.99
76	0	2	2.91	73	0	2	2.05	71	0	2	2.15
77	0	2	4.	74	0	2	3.17	72	0	2	3.31
78	0	2	5.09	75	0	2	4.3	73	0	2	4.46
79	0	2	6.18	76	0	2	5.42	74	0	2	5.62
80	0	2	7.27	77	0	2	6.55	75	0	2	6.78

Dimensions.	Statute content.		
Yards	A.	R.	P.
35 by 76	0	2	7.93
77	0	2	9.09
78	0	2	10.25
79	0	2	11.4
80	0	2	12.56
81	0	2	13.72
82	0	2	14.88
83	0	2	16.03
84	0	2	17.19
85	0	2	18.35
86	0	2	19.5
87	0	2	20.66
88	0	2	21.82
89	0	2	22.98
90	0	2	24.13
91	0	2	25.29
92	0	2	26.45
93	0	2	27.6
94	0	2	28.76
95	0	2	29.92
96	0	2	31.07
97	0	2	32.23
98	0	2	33.39
99	0	2	34.55
100	0	2	35.7
36 by 36	0	1	2.84
37	0	1	4.03
38	0	1	5.22
39	0	1	6.41
40	0	1	7.6
41	0	1	8.79
42	0	1	9.98
43	0	1	11.17
44	0	1	12.36
45	0	1	13.55
46	0	1	14.74
47	0	1	15.93
48	0	1	17.12
49	0	1	18.31
50	0	1	19.5
51	0	1	20.69
52	0	1	21.88
53	0	1	23.07
54	0	1	24.26
55	0	1	25.45
56	0	1	26.64
57	0	1	27.83
58	0	1	29.02
59	0	1	30.21
60	0	1	31.4
61	0	1	32.6
62	0	1	33.79
63	0	1	34.98
64	0	1	36.17
65	0	1	37.36
66	0	1	38.55
67	0	1	39.74
68	0	2	0.93
69	0	2	2.12
70	0	2	3.31
71	0	2	4.5
72	0	2	5.69
73	0	2	6.88
74	0	2	8.07

Dimensions.	Statute content.		
Yards.	A.	R.	P.
36 by 75	0	2	9.26
76	0	2	10.45
77	0	2	11.64
78	0	2	12.83
79	0	2	14.02
80	0	2	15.21
81	0	2	16.4
82	0	2	17.59
83	0	2	18.78
84	0	2	19.97
85	0	2	21.16
86	0	2	22.35
87	0	2	23.54
88	0	2	24.73
89	0	2	25.92
90	0	2	27.11
91	0	2	28.3
92	0	2	29.49
93	0	2	30.68
94	0	2	31.87
95	0	2	33.06
96	0	2	34.25
97	0	2	35.44
98	0	2	36.63
99	0	2	37.82
100	0	2	39.01
37 by 37	0	1	5.26
38	0	1	6.48
39	0	1	7.7
40	0	1	8.93
41	0	1	10.15
42	0	1	11.37
43	0	1	12.6
44	0	1	13.82
45	0	1	15.04
46	0	1	16.26
47	0	1	17.49
48	0	1	18.71
49	0	1	19.93
50	0	1	21.16
51	0	1	22.38
52	0	1	23.6
53	0	1	24.83
54	0	1	26.05
55	0	1	27.27
56	0	1	28.5
57	0	1	29.72
58	0	1	30.94
59	0	1	32.17
60	0	1	33.39
61	0	1	34.61
62	0	1	35.83
63	0	1	37.06
64	0	1	38.28
65	0	1	39.5
66	0	2	0.73
67	0	2	1.95
68	0	2	3.17
69	0	2	4.4
70	0	2	5.62
71	0	2	6.84
72	0	2	8.07
73	0	2	9.29
74	0	2	10.51

Dimensions.	Statute content.		
Yards.	A.	R.	P.
37 by 75	0	2	11.74
76	0	2	12.96
77	0	2	14.18
78	0	2	15.4
79	0	2	16.63
80	0	2	17.85
81	0	2	19.07
82	0	2	20.3
83	0	2	21.52
84	0	2	22.74
85	0	2	23.97
86	0	2	25.19
87	0	2	26.41
88	0	2	27.64
89	0	2	28.86
90	0	2	30.08
91	0	2	31.31
92	0	2	32.53
93	0	2	33.75
94	0	2	34.98
95	0	2	36.2
96	0	2	37.42
97	0	2	38.64
98	0	2	39.87
99	0	3	1.09
100	0	3	2.31
38 by 38	0	1	7.74
39	0	1	8.99
40	0	1	10.25
41	0	1	11.5
42	0	1	12.76
43	0	1	14.02
44	0	1	15.27
45	0	1	16.53
46	0	1	17.79
47	0	1	19.04
48	0	1	20.3
49	0	1	21.55
50	0	1	22.81
51	0	1	24.07
52	0	1	25.32
53	0	1	26.58
54	0	1	27.83
55	0	1	29.09
56	0	1	30.35
57	0	1	31.6
58	0	1	32.86
59	0	1	34.12
60	0	1	35.37
61	0	1	36.63
62	0	1	37.88
63	0	1	39.14
64	0	2	0.4
65	0	2	1.65
66	0	2	2.91
67	0	2	4.17
68	0	2	5.42
69	0	2	6.68
70	0	2	7.93
71	0	2	9.19
72	0	2	10.45
73	0	2	11.7
74	0	2	12.96
75	0	2	14.21

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
38 by 76	0	2	15.47	**39** by 78	0	2	20.56	**40** by 81	0	2	27·11
77	0	2	16.73	79	0	2	21.85	82	0	2	28.43
78	0	2	17.97	80	0	2	23.14	83	0	2	29.75
79	0	2	19.24	81	0	2	24.43	84	0	2	31.07
80	0	2	20.5	82	0	2	25.72	85	0	2	32.4
81	0	2	21.75	83	0	2	27.01	86	0	2	33.72
82	0	2	23.01	84	0	2	28.3	87	0	2	35.04
83	0	2	24.26	85	0	2	29.59	88	0	2	36.36
84	0	2	25.52	86	0	2	30.88	89	0	2	37.69
85	0	2	26.78	87	0	2	32.17	90	0	2	39.01
86	0	2	28.03	88	0	2	33.45	91	0	3	0.33
87	0	2	29.29	89	0	2	34.74	92	0	3	1.65
88	0	2	30.55	90	0	2	36.03	93	0	3	2.98
89	0	2	31.8	91	0	2	37.32	94	0	3	4.3
90	0	2	33.06	92	0	2	38.61	95	0	3	5.62
91	0	2	34.31	93	0	2	39.9	96	0	3	6.94
92	0	2	35.58	94	0	3	1.19	97	0	3	8.26
93	0	2	36.83	95	0	3	2.48	98	0	3	9.59
94	0	2	38.08	96	0	3	3.77	99	0	3	10.91
95	0	2	39.34	97	0	3	5.06	100	0	3	12.23
96	0	3	0.6	98	0	3	6.35	**41** by 41	0	1	15.57
97	0	3	1.85	99	0	3	7.64	42	0	1	16.93
98	0	3	3.11	100	0	3	8.93	43	0	1	18.28
99	0	3	4.36	**40** by 40	0	1	12.89	44	0	1	19.64
100	0	3	5.62	41	0	1	14.21	45	0	1	20.99
39 by 39	0	1	10.28	42	0	1	15.54	46	0	1	22.35
40	0	1	11.57	43	0	1	16.86	47	0	1	23.7
41	0	1	12.86	44	0	1	18.18	48	0	1	25.06
42	0	1	14.15	45	0	1	19.5	49	0	1	26.41
43	0	1	15.44	46	0	1	20.83	50	0	1	27.77
44	0	1	16.73	47	0	1	22.15	51	0	1	29.12
45	0	1	18.02	48	0	1	23.47	52	0	1	30.48
46	0	1	19.31	49	0	1	24·79	53	0	1	31.83
47	0	1	20.6	50	0	1	26.12	54	0	1	33.19
48	0	1	21.88	51	0	1	27.44	55	0	1	34.55
49	0	1	23.17	52	0	1	28.76	56	0	1	35.9
50	0	1	24.46	53	0	1	30.08	57	0	1	37.26
51	0	1	25.75	54	0	1	31.4	58	0	1	38.61
52	0	1	27.04	55	0	1	32.73	59	0	1	39.97
53	0	1	28.33	56	0	1	34.05	60	0	2	1.32
54	0	1	29.62	57	0	1	35.37	61	0	2	2.68
55	0	1	30.91	58	0	1	36.69	62	0	2	4.03
56	0	1	32.2	59	0	1	38.02	63	0	2	5.39
57	0	1	33.49	60	0	1	39.34	64	0	2	6.74
58	0	1	34.78	61	0	2	0.66	65	0	2	8.1
59	0	1	36.07	62	0	2	1.98	66	0	2	9.45
60	0	1	37.36	63	0	2	3.31	67	0	2	10.81
61	0	1	38.64	64	0	2	4.63	68	0	2	12.17
62	0	1	39.93	65	0	2	5.95	69	0	2	13.52
63	0	2	1.22	66	0	2	7.27	70	0	2	14.88
64	0	2	2.51	67	0	2	8.6	71	0	2	16.23
65	0	2	3.8	68	0	2	9.92	72	0	2	17.59
66	0	2	5.09	69	0	2	11.24	73	0	2	18.94
67	0	2	6.38	70	0	2	12.56	74	0	2	20.3
68	0	2	7.67	71	0	2	13.88	75	0	2	21.65
69	0	2	8.96	72	0	2	15.21	76	0	2	23.01
70	0	2	10.25	73	0	2	16.53	77	0	2	24.36
71	0	2	11.54	74	0	2	17.85	78	0	2	25.72
72	0	2	12.83	75	0	2	19.17	79	0	2	27.07
73	0	2	14.12	76	0	2	20.5	80	0	2	28.43
74	0	2	15.4	77	0	2	21.82	81	0	2	29.79
75	0	2	16.69	78	0	2	23.14	82	0	2	31.14
76	0	2	17.98	79	0	2	24.46	83	0	2	32.5
77	0	2	19.27	80	0	2	25.79	84	0	2	33.85

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
41 by 85	0	2	35.21	**42** by 90	0	3	4.96	**43** by 96	0	3	16.46
86	0	2	36.56	91	0	3	6.35	97	0	3	17.88
87	0	2	37.92	92	0	3	7.74	98	0	3	19.31
88	0	2	39.27	93	0	3	9.12	99	0	3	20.73
89	0	3	0.63	94	0	3	10.51	100	0	3	22.15
90	0	3	1.98	95	0	3	11.9	**44** by 44	0	1	24.
91	0	3	3.34	96	0	3	13.29	45	0	1	25.45
92	0	3	4.69	97	0	3	14.68	46	0	1	26.91
93	0	3	6.05	98	0	3	16.07	47	0	1	28.36
94	0	3	7.4	99	0	3	17.45	48	0	1	29.82
95	0	3	8.76	100	0	3	18.84	49	0	1	31.27
96	0	3	10.12	**43** by 43	0	1	21·12	50	0	1	32.73
97	0	3	11.47	44	0	1	22.55	51	0	1	34.18
98	0	3	12.83	45	0	1	23.97	52	0	1	35.64
99	0	3	14.18	46	0	1	25.39	53	0	1	37.09
100	0	3	15.54	47	0	1	26.81	54	0	1	38.55
42 by 42	0	1	18.31	48	0	1	28.23	55	0	2	0.
43	0	1	19.7	49	0	1	29.65	56	0	2	1.45
44	0	1	21.09	50	0	1	31.07	57	0	2	2.91
45	0	1	22.48	51	0	1	32.5	58	0	2	4.36
46	0	1	23.87	52	0	1	33.92	59	0	2	5.82
47	0	1	25.26	53	0	1	35.34	60	0	2	7.27
48	0	1	26.64	54	0	1	36.76	61	0	2	8.73
49	0	1	28.03	55	0	1	38.18	62	0	2	10.18
50	0	1	29.42	56	0	1	39.6	63	0	2	11.64
51	0	1	30.81	57	0	2	1.02	64	0	2	13.09
52	0	1	32.2	58	0	2	2.45	65	0	2	14.55
53	0	1	33.59	59	0	2	3.87	66	0	2	16.
54	0	1	34.98	60	0	2	5.29	67	0	2	17.45
55	0	1	36.36	61	0	2	6.71	68	0	2	18.91
56	0	1	37.75	62	0	2	8.13	69	0	2	20.36
57	0	1	39.14	63	0	2	9.55	70	0	2	21.82
58	0	2	0.53	64	0	2	10.98	71	0	2	23.27
59	0	2	1.92	65	0	2	12.4	72	0	2	24.73
60	0	2	3.31	66	0	2	13.82	73	0	2	26.18
61	0	2	4.69	67	0	2	15.24	74	0	2	27.64
62	0	2	6.08	68	0	2	16.66	75	0	2	29.09
63	0	2	7.47	69	0	2	18.08	76	0	2	30.55
64	0	2	8.86	70	0	2	19.5	77	0	2	32.
65	0	2	10.25	71	0	2	20.93	78	0	2	33.45
66	0	2	11.64	72	0	2	22·35	79	0	2	34.91
67	0	2	13.02	73	0	2	23.77	80	0	2	36.36
68	0	2	14.41	74	0	2	25.19	81	0	2	37.82
69	0	2	15.8	75	0	2	26.61	82	0	2	39.27
70	0	2	17.19	76	0	2	28.03	83	0	3	0.73
71	0	2	18.58	77	0	2	29.45	84	0	3	2.18
72	0	2	19.97	78	0	2	30.88	85	0	3	3.64
73	0	2	21.36	79	0	2	32.3	86	0	3	5.09
74	0	2	22.74	80	0	2	33.72	87	0	3	6.55
75	0	2	24.13	81	0	2	35.14	88	0	3	8.
76	0	2	25.52	82	0	2	36.56	89	0	3	9.45
77	0	2	26.91	83	0	2	37.98	90	0	3	10.91
78	0	2	28.3	84	0	2	39.4	91	0	3	12.36
79	0	2	29.69	85	0	3	0.83	92	0	3	13.82
80	0	2	31.07	86	0	3	2.25	93	0	3	15.27
81	0	2	32.46	87	0	3	3.67	94	0	3	16.73
82	0	2	33.85	88	0	3	5.09	95	0	3	18.18
83	0	2	35.24	89	0	3	6.51	96	0	3	19.64
84	0	2	36.63	90	0	3	7.93	97	0	3	21.09
85	0	2	38.02	91	0	3	9.36	98	0	3	22.55
86	0	2	39.4	92	0	3	10.78	99	0	3	24.
87	0	3	0.79	93	0	3	12.2	100	0	3	25.45
88	0	3	2.18	94	0	3	13.62	**45** by 45	0	1	26.94
89	0	3	3·57	95	0	3	15.04	46	0	1	28.43

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
45 by 47	0	1	29.92	**46** by 56	0	2	5.16	**47** by 66	0	2	22.55
48	0	1	31.4	57	0	2	6.68	67	0	2	24.1
49	0	1	32.89	58	0	2	8.2	68	0	2	25.65
50	0	1	34.38	59	0	2	9.72	69	0	2	27.21
51	0	1	35.87	60	0	2	11.24	70	0	2	28.76
52	0	1	37.36	61	0	2	12.76	71	0	2	30.31
53	0	1	38.84	62	0	2	14.28	72	0	2	31.87
54	0	2	0.33	63	0	2	15.8	73	0	2	33.42
55	0	2	1.82	64	0	2	17.32	74	0	2	34.98
56	0	2	3.31	65	0	2	18.84	75	0	2	36.53
57	0	2	4.79	66	0	2	20.36	76	0	2	38.08
58	0	2	6.28	67	0	2	21.88	77	0	2	39.64
59	0	2	7.77	68	0	2	23.4	78	0	3	1.19
60	0	2	9·26	69	0	2	24.93	79	0	3	2.74
61	0	2	10.74	70	0	2	26.45	80	0	3	4.3
62	0	2	12.23	71	0	2	27.97	81	0	3	5.85
63	0	2	13.72	72	0	2	29.49	82	0	3	7.4
64	0	2	15.21	73	0	2	31.01	83	0	3	8.96
65	0	2	16.69	74	0	2	32.53	84	0	3	10.51
66	0	2	18.18	75	0	2	34.05	85	0	3	12.07
67	0	2	19.67	76	0	2	35.57	86	0	3	13 62
68	0	2	21.16	77	0	2	37.09	87	0	3	15.17
69	0	2	22.64	78	0	2	38.61	88	0	3	16.73
70	0	2	24.13	79	0	3	0.13	89	0	3	18.28
71	0	2	25.62	80	0	3	1.65	90	0	3	19.83
72	0	2	27.11	81	0	3	3.17	91	0	3	21.39
73	0	2	28.6	82	0	3	4.69	92	0	3	22-94
74	0	2	30.08	83	0	3	6.21	93	0	3	24.5
75	0	2	31.57	84	0	3	7.74	94	0	3	26.05
76	0	2	33.06	85	0	3	9.26	95	0	3	27.6
77	0	2	34.55	86	0	3	10.78	96	0	3	29.16
78	0	2	36.03	87	0	3	12.3	97	0	3	30.71
79	0	2	37.52	88	0	3	13.82	98	0	3	32.26
80	0	2	39.01	89	0	3	15.34	99	0	3	33.82
81	0	3	0.5	90	0	3	16.86	100	0	3	35.37
82	0	3	1.98	91	0	3	18.38	**48** by 48	0	1	36.17
83	0	3	3.47	92	0	3	19.9	49	0	1	37.75
84	0	3	4.96	93	0	3	21.42	50	0	1	39.34
85	0	3	6.45	94	0	3	22.94	51	0	2	0.93
86	0	3	7.93	95	0	3	24.46	52	0	2	2.51
87	0	3	9.42	96	0	3	25.98	53	0	2	4.1
88	0	3	10.91	97	0	3	27.5	54	0	2	5.69
89	0	3	12.4	98	0	3	29.02	55	0	2	7.27
90	0	3	13.88	99	0	3	30.55	56	0	2	8.86
91	0	3	15.37	100	0	3	32.07	57	0	2	10.45
92	0	3	16.86	**47** by 47	0	1	33.02	58	0	2	12.03
93	0	3	18.35	48	0	1	34.58	59	0	2	13.62
94	0	3	19.83	49	0	1	36.13	60	0	2	15.21
95	0	3	21.32	50	0	1	37.69	61	0	2	16.79
96	0	3	22.81	51	0	1	39.24	62	0	2	18.38
97	0	3	24.3	52	0	2	0.79	63	0	2	19.97
98	0	3	25.79	53	0	2	2.35	64	0	2	21.55
99	0	3	27.27	54	0	2	3.9	65	0	2	23.14
100	0	3	28.76	55	0	2	5.45	66	0	2	24.73
46 by 46	0	1	29.95	56	0	2	7.01	67	0	2	26.31
47	0	1	31.47	57	0	2	8.56	68	0	2	27.9
48	0	1	32.99	58	0	2	10.12	69	0	2	29.49
49	0	1	34.51	59	0	2	11.67	70	0	2	31.07
50	0	1	36.03	60	0	2	13.22	71	0	2	32.66
51	0	1	37.55	61	0	2	14.78	72	0	2	34.25
52	0	1	39.07	62	0	2	16.33	73	0	2	35.83
53	0	2	0.6	63	0	2	17.88	74	0	2	37.42
54	0	2	2.12	64	0	2	19.44	75	0	2	39.01
55	0	2	3.64	65	0	2	20.99	76	0	3	0.6

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
48 by 77	0	3	2.18	**49** by 89	0	3	24.17	**51** by 52	0	2	7.67
78	0	3	3.77	90	0	3	25.79	53	0	2	9.36
79	0	3	5.36	91	0	3	27.4	54	0	2	11.04
80	0	3	6.94	92	0	3	29.02	55	0	2	12.73
81	0	3	8.53	93	0	3	30.64	56	0	2	14.41
82	0	3	10.12	94	0	3	32.26	57	0	2	16.1
83	0	3	11.7	95	0	3	33.88	58	0	2	17.79
84	0	3	13.29	96	0	3	35.5	59	0	2	19.47
85	0	3	14.88	97	0	3	37.12	60	0	2	21.16
86	0	3	16.46	98	0	3	38.74	61	0	2	22.84
87	0	3	18.05	99	1	0	0.36	62	0	2	24.53
88	0	3	19.64	100	1	0	1.98	63	0	2	26.21
89	0	3	21.22	**50** by 50	0	2	2.64	64	0	2	27.9
90	0	3	22.81	51	0	2	4.3	65	0	2	29.59
91	0	3	24.4	52	0	2	5.95	66	0	2	31.27
92	0	3	25.98	53	0	2	7.6	67	0	2	32.96
93	0	3	27.57	54	0	2	9.26	68	0	2	34.64
94	0	3	29.16	55	0	2	10.91	69	0	2	36.33
95	0	3	30.74	56	0	2	12.56	70	0	2	38.02
96	0	3	32.33	57	0	2	14.21	71	0	2	39.7
97	0	3	33.92	58	0	2	15.87	72	0	3	1.39
98	0	3	35.5	59	0	2	17.52	73	0	3	3.07
99	0	3	37.09	60	0	2	19.17	74	0	3	4.76
100	0	3	38.68	61	0	2	20.83	75	0	3	6.45
49 by 49	0	1	39.37	62	0	2	22.48	76	0	3	8.13
50	0	2	0.99	63	0	2	24.13	77	0	3	9.82
51	0	2	2.61	64	0	2	25.79	78	0	3	11.5
52	0	2	4.23	65	0	2	27.44	79	0	3	13.19
53	0	2	5.85	66	0	2	29.09	80	0	3	14.88
54	0	2	7.47	67	0	2	30.74	81	0	3	16.56
55	0	2	9.09	68	0	2	32.4	82	0	3	18.25
56	0	2	10.71	69	0	2	34.05	83	0	3	19.93
57	0	2	12.33	70	0	2	35.7	84	0	3	21.62
58	0	2	13.95	71	0	2	37.36	85	0	3	23.31
59	0	2	15.57	72	0	2	39.01	86	0	3	24.99
60	0	2	17.19	73	0	3	0.66	87	0	3	26.68
61	0	2	18.81	74	0	3	2.31	88	0	3	28.36
62	0	2	20.43	75	0	3	3.97	89	0	3	30.05
63	0	2	22.05	76	0	3	5.62	90	0	3	31.74
64	0	2	23.67	77	0	3	7.27	91	0	3	33.42
65	0	2	25.29	78	0	3	8.93	92	0	3	35.11
66	0	2	26.91	79	0	3	10.58	93	0	3	36.79
67	0	2	28.53	80	0	3	12.23	94	0	3	38.48
68	0	2	30.15	81	0	3	13.88	95	1	0	0.17
69	0	2	31.77	82	0	3	15.54	96	1	0	1.85
70	0	2	33.39	83	0	3	17.19	97	1	0	3.54
71	0	2	35.01	84	0	3	18.84	98	1	0	5.22
72	0	2	36.63	85	0	3	20.5	99	1	0	6.91
73	0	2	38.25	86	0	3	22.15	100	1	0	8.6
74	0	2	39.87	87	0	3	23.8	**52** by 52	0	2	9.39
75	0	3	1.49	88	0	3	25.45	53	0	2	11.11
76	0	3	3.11	89	0	3	27.11	54	0	2	12.83
77	0	3	4.73	90	0	3	28.76	55	0	2	14.55
78	0	3	6.35	91	0	3	30.41	56	0	2	16.26
79	0	3	7.97	92	0	3	32.07	57	0	2	17.98
80	0	3	9.59	93	0	3	33.72	58	0	2	19.7
81	0	3	11.21	94	0	3	35.37	59	0	2	21.42
82	0	3	12.83	95	0	3	37.02	60	0	2	23.14
83	0	3	14.45	96	0	3	38.68	61	0	2	24.86
84	0	3	16.07	97	1	0	0.33	62	0	2	26.58
85	0	3	17.69	98	1	0	1.98	63	0	2	28.3
86	0	3	19.31	99	1	0	3.64	64	0	2	30.02
87	0	3	20.93	100	1	0	5.29	65	0	2	31.74
88	0	3	22.55	**51** by 51	0	2	5.98	66	0	2	33.45

Dimensions.	Statute content.	Dimensions.	Statute content.	Dimensions.	Statute content.
Yards.	A. R. P.	Yards.	A. R. P.	Yards.	A. R. P.
52 by 67	0 2 35.17	53 by 83	0 3 25.42	54 by 100	1 0 18.51
68	0 2 36.89	84	0 3 27.17	55 by 55	0 2 20.
69	0 2 38.61	85	0 3 28.93	56	0 2 21.82
70	0 3 0.33	86	0 3 30.68	57	0 2 23.64
71	0 3 2.05	87	0 3 32.43	58	0 2 25.45
72	0 3 3.77	88	0 3 34.18	59	0 2 27.27
73	0 3 5.49	89	0 3 35.93	60	0 2 29.09
74	0 3 7.21	90	0 3 37.69	61	0 2 30.91
75	0 3 8.93	91	0 3 39.44	62	0 2 32.73
76	0 3 10.64	92	1 0 1.19	63	0 2 34.55
77	0 3 12.36	93	1 0 2.94	64	0 2 36.36
78	0 3 14.08	94	1 0 4.69	65	0 2 38.18
79	0 3 15.8	95	1 0 6.45	66	0 3 0.
80	0 3 17.52	96	1 0 8.2	67	0 3 1.82
81	0 3 19.24	97	1 0 9.95	68	0 3 3.64
82	0 3 20.96	98	1 0 11.7	69	0 3 5.45
83	0 3 22.68	99	1 0 13.45	70	0 3 7.27
84	0 3 24.4	100	1 0 15.21	71	0 3 9.09
85	0 3 26.12	54 by 54	0 2 16.4	72	0 3 10.91
86	0 3 27.83	55	0 2 18.18	73	0 3 12.73
87	0 3 29.55	56	0 2 19.97	74	0 3 14.55
88	0 3 31.27	57	0 2 21.75	75	0 3 16.36
89	0 3 32.99	58	0 2 23.54	76	0 3 18.18
90	0 3 34.71	59	0 2 25.32	77	0 3 20.
91	0 3 36.43	60	0 2 27.11	78	0 3 21.82
92	0 3 38.15	61	0 2 28·89	79	0 3 23.64
93	0 3 39.87	62	0 2 30.68	80	0 3 25.45
94	1 0 1.59	63	0 2 32.46	81	0 3 27.27
95	1 0 3.31	64	0 2 34.25	82	0 3 29.09
96	1 0 5.02	65	0 2 36.03	83	0 3 30.91
97	1 0 6.74	66	0 2 37.82	84	0 3 32.73
98	1 0 8.46	67	0 2 39.6	85	0 3 34.55
99	1 0 10.18	68	0 3 1.39	86	0 3 36.36
100	1 0 11.9	69	0 3 3.17	87	0 3 38·18
53 by 53	0 2 12·86	70	0 3 4.96	88	1 0 0.
54	0 2 14.61	71	0 3 6.74	89	1 0 1.82
55	0 2 16.36	72	0 3 8.53	90	1 0 3.64
56	0 2 18.12	73	0 3 10.31	91	1 0 5.45
57	0 2 19.87	74	0 3 12.1	92	1 0 7.27
58	0 2 21.62	75	0 3 13.88	93	1 0 9.09
59	0 2 23.37	76	0 3 15.67	94	1 0 10.91
60	0 2 25.12	77	0 3 17.45	95	1 0 12.73
61	0 2 26.88	78	0 3 19.24	96	1 0 14.55
62	0 2 28.63	79	0 3 21.02	97	1 0 16.36
63	0 2 30.38	80	0 3 22.81	98	1 0 18.18
64	0 2 32.13	81	0 3 24.6	99	1 0 20.
65	0 2 33.88	82	0 3 26.38	100	1 0 21.82
66	0 2 35.64	83	0 3 28.17	56 by 56	0 2 23.67
67	0 2 37.39	84	0 3 29.95	57	0 2 25.52
68	0 2 39.14	85	0 3 31.74	58	0 2 27.37
69	0 3 0.89	86	0 3 33.52	59	0 2 29.22
70	0 3 2.64	87	0 3 35.31	60	0 2 31.07
71	0 3 4.4	88	0 3 37.09	61	0 2 32.93
72	0 3 6.15	89	0 3 38.88	62	0 2 34.78
73	0 3 7.9	90	1 0 0.66	63	0 2 36.63
74	0 3 9.65	91	1 0 2.45	64	0 2 38.48
75	0 3 11.4	92	1 0 4.23	65	0 3 0.33
76	0 3 13.16	93	1 0 6.02	66	0 3 2.18
77	0 3 14.91	94	1 0 7.8	67	0 3 4.03
78	0 3 16.66	95	1 0 9.59	68	0 3 5.88
79	0 3 18.41	96	1 0 11.37	69	0 3 7.74
80	0 3 20.17	97	1 0 13.16	70	0 3 9.59
81	0 3 21.92	98	1 0 14.94	71	0 3 11.44
82	0 3 23.67	99	1 0 16.73	72	0 3 13.29

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
56 by 73	0	3	15.14	**57** by 93	1	0	15.24	**59** by 72	0	3	20.43
74	0	3	16.99	94	1	0	17.12	73	0	3	22.38
75	0	3	18.84	95	1	0	19.01	74	0	3	24.33
76	0	3	20.69	96	1	0	20.89	75	0	3	26.28
77	0	3	22.55	97	1	0	22.78	76	0	3	28.23
78	0	3	24.4	98	1	0	24.66	77	0	3	30.18
79	0	3	26.25	99	1	0	26.55	78	0	3	32.13
80	0	3	28.1	100	1	0	28.43	79	0	3	34.08
81	0	3	29.95	**58** by 58	0	2	31.21	80	0	3	36.03
82	0	3	31.8	59	0	2	33.12	81	0	3	37.98
83	0	3	33.65	60	0	2	35.04	82	0	3	39.93
84	0	3	35.5	61	0	2	36.96	83	1	0	1.88
85	0	3	37.36	62	0	2	38.88	84	1	0	3.83
86	0	3	39.21	63	0	3	0.79	85	1	0	5.79
87	1	0	1.06	64	0	3	2.71	86	1	0	7.74
88	1	0	2.91	65	0	3	4.63	87	1	0	9.69
89	1	0	4.76	66	0	3	6.55	88	1	0	11.64
90	1	0	6.61	67	0	3	8.46	89	1	0	13.59
91	1	0	8.46	68	0	3	10.38	90	1	0	15.54
92	1	0	10.31	69	0	3	12.3	91	1	0	17.49
93	1	0	12.17	70	0	3	14.21	92	1	0	19.44
94	1	0	14.02	71	0	3	16.13	93	1	0	21.39
95	1	0	15.87	72	0	3	18.05	94	1	0	23.34
96	1	0	17.72	73	0	3	19.97	95	1	0	25.29
97	1	0	19.57	74	0	3	21.88	96	1	0	27.24
98	1	0	21.42	75	0	3	23.8	97	1	0	29.19
99	1	0	23.27	76	0	3	25.72	98	1	0	31.14
100	1	0	25.12	77	0	3	27.64	99	1	0	33.09
57 by 57	0	2	27.4	78	0	3	29.55	100	1	0	35.04
58	0	2	29.29	79	0	3	31.47	**60** by 60	0	2	39.01
59	0	2	31.17	80	0	3	33.39	61	0	3	0.99
60	0	2	33.06	81	0	3	35.31	62	0	3	2.98
61	0	2	34.94	82	0	3	37.22	63	0	3	4.96
62	0	2	36.83	83	0	3	39.14	64	0	3	6.94
63	0	2	38.71	84	1	0	1.06	65	0	3	8.93
64	0	3	0.6	85	1	0	2.98	66	0	3	10.91
65	0	3	2.48	86	1	0	4.89	67	0	3	12.89
66	0	3	4.36	87	1	0	6.81	68	0	3	14.88
67	0	3	6.25	88	1	0	8.73	69	0	3	16.86
68	0	3	8.13	89	1	0	10.64	70	0	3	18.84
69	0	3	10.02	90	1	0	12.56	71	0	3	20.83
70	0	3	11.9	91	1	0	14.48	72	0	3	22.81
71	0	3	13.79	92	1	0	16.4	73	0	3	24.79
72	0	3	15.67	93	1	0	18.31	74	0	3	26.78
73	0	3	17.55	94	1	0	20.23	75	0	3	28.76
74	0	3	19.44	95	1	0	22.15	76	0	3	30.74
75	0	3	21.32	96	1	0	24.07	77	0	3	32.73
76	0	3	23.21	97	1	0	25.98	78	0	3	34.71
77	0	3	25.09	98	1	0	27.9	79	0	3	36.69
78	0	3	26.98	99	1	0	29.82	80	0	3	38.68
79	0	3	28.86	100	1	0	31.74	81	1	0	0.66
80	0	3	30.74	**59** by 59	0	2	35.07	82	1	0	2.64
81	0	3	32.63	60	0	2	37.02	83	1	0	4.63
82	0	3	34.51	61	0	2	38.98	84	1	0	6.61
83	0	3	36.4	62	0	3	0.93	85	1	0	8.6
84	0	3	38.28	63	0	3	2.88	86	1	0	10.58
85	1	0	0.17	64	0	3	4.83	87	1	0	12.56
86	1	0	2.05	65	0	3	6.78	88	1	0	14.55
87	1	0	3.93	66	0	3	8.73	89	1	0	16.53
88	1	0	5.82	67	0	3	10.68	90	1	0	18.51
89	1	0	7.7	68	0	3	12.63	91	1	0	20.5
90	1	0	9.59	69	0	3	14.58	92	1	0	22.48
91	1	0	11.47	70	0	3	16.53	93	1	0	24.46
92	1	0	13.36	71	0	3	18.48	94	1	0	26.45

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
60 by 95	1	0	28.43	**62** by 80	1	0	3.97	**64** by 69	0	3	25.98
96	1	0	30.41	81	1	0	6.02	70	0	3	28.1
97	1	0	32.4	82	1	0	8.07	71	0	3	30.21
98	1	0	34.38	83	1	0	10.12	72	0	3	32.33
99	1	0	36.36	84	1	0	12.17	73	0	3	34.45
100	1	0	38.35	85	1	0	14.21	74	0	3	36.56
61 by 61	0	3	3.01	86	1	0	16.26	75	0	3	38.68
62	0	3	5.02	87	1	0	18.31	76	1	0	0.79
63	0	3	7.04	88	1	0	20.36	77	1	0	2.91
64	0	3	9.06	89	1	0	22.41	78	1	0	5.02
65	0	3	11.07	90	1	0	24.46	79	1	0	7.14
66	0	3	13.09	91	1	0	26.51	80	1	0	9.26
67	0	3	15.11	92	1	0	28.56	81	1	0	11.37
68	0	3	17.12	93	1	0	30.61	82	1	0	13.49
69	0	3	19.14	94	1	0	32.66	83	1	0	15.6
70	0	3	21.16	95	1	0	34.71	84	1	0	17.72
71	0	3	23.17	96	1	0	36.76	85	1	0	19.83
72	0	3	25.19	97	1	0	38.81	86	1	0	21.95
73	0	3	27.21	98	1	1	0.86	87	1	0	24.07
74	0	3	29.22	99	1	1	2.91	88	1	0	26.18
75	0	3	31.24	100	1	1	4.96	89	1	0	28.3
76	0	3	33.26	**63** by 63	0	3	11.21	90	1	0	30.41
77	0	3	35.27	64	0	3	13.29	91	1	0	32.53
78	0	3	37.29	65	0	3	15.37	92	1	0	34.64
79	0	3	39.31	66	0	3	17.45	93	1	0	36.76
80	1	0	1.32	67	0	3	19.54	94	1	0	38.88
81	1	0	3.34	68	0	3	21.62	95	1	1	0.99
82	1	0	5.36	69	0	3	23.7	96	1	1	3.11
83	1	0	7.37	70	0	3	25.79	97	1	1	5.22
84	1	0	9.39	71	0	3	27.87	98	1	1	7.34
85	1	0	11.4	72	0	3	29.95	99	1	1	9.45
86	1	0	13.42	73	0	3	32.03	100	1	1	11.57
87	1	0	15.44	74	0	3	34.12	**65** by 65	0	3	19.67
88	1	0	17.45	75	0	3	36.2	66	0	3	21.82
89	1	0	19.47	76	0	3	38.28	67	0	3	23.97
90	1	0	21.49	77	1	0	0.36	68	0	3	26.12
91	1	0	23.5	78	1	0	2.45	69	0	3	28.26
92	1	0	25.52	79	1	0	4.53	70	0	3	30.41
93	1	0	27.54	80	1	0	6.61	71	0	3	32.56
94	1	0	29.55	81	1	0	8.69	72	0	3	34.71
95	1	0	31.57	82	1	0	10.78	73	0	3	36.86
96	1	0	33.59	83	1	0	12.86	74	0	3	39.01
97	1	0	35.6	84	1	0	14.94	75	1	0	1.16
98	1	0	37.62	85	1	0	17.02	76	1	0	3.31
99	1	0	39.64	86	1	0	19.11	77	1	0	5.45
100	1	1	1.65	87	1	0	21.19	78	1	0	7.6
62 by 62	0	3	7.07	88	1	0	23.27	79	1	0	9.75
63	0	3	9.12	89	1	0	25.36	80	1	0	11.9
64	0	3	11.17	90	1	0	27.44	81	1	0	14.05
65	0	3	13.22	91	1	0	29.52	82	1	0	16.2
66	0	3	15.27	92	1	0	31.6	83	1	0	18.35
67	0	3	17.32	93	1	0	33.69	84	1	0	20.5
68	0	3	19.37	94	1	0	35.77	85	1	0	22.64
69	0	3	21.42	95	1	0	37.85	86	1	0	24.79
70	0	3	23.47	96	1	0	39.93	87	1	0	26.94
71	0	3	25.52	97	1	1	2.02	88	1	0	29.09
72	0	3	27.57	98	1	1	4.1	89	1	0	31.24
73	0	3	29.62	99	1	1	6.18	90	1	0	33.39
74	0	3	31.67	100	1	1	8.26	91	1	0	35.54
75	0	3	33.72	**64** by 64	0	3	15.4	92	1	0	37.69
76	0	3	35.77	65	0	3	17.52	93	1	0	39.83
77	0	3	37.82	66	0	3	19.64	94	1	1	1.98
78	0	3	39.87	67	0	3	21.75	95	1	1	4.13
79	1	0	1.92	68	0	3	23.87	96	1	1	6.28

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
65 by 97	1	1	8.43	**67** by 92	1	1	3.77	**69** by 91	1	1	7.57
98	1	1	10.58	93	1	1	5.98	92	1	1	9.85
99	1	1	12.73	94	1	1	8.2	93	1	1	12.13
100	1	1	14.88	95	1	1	10.41	94	1	1	14.41
66 by 66	0	3	24.	96	1	1	12.63	95	1	1	16.69
67	0	3	26.18	97	1	1	14.84	96	1	1	18.98
68	0	3	28.36	98	1	1	17.06	97	1	1	21.26
69	0	3	30.55	99	1	1	19.27	98	1	1	23.54
70	0	3	32.73	100	1	1	21.48	99	1	1	25.82
71	0	3	34.91	**68** by 68	0	3	32.86	100	1	1	28.1
72	0	3	37.09	69	0	3	35.11	**70** by 70	1	0	1.98
73	0	3	39.27	70	0	3	37.36	71	1	0	4.3
74	1	0	1.45	71	0	3	39.6	72	1	0	6.61
75	1	0	3.64	72	1	0	1.85	73	1	0	8.93
76	1	0	5.82	73	1	0	4.1	74	1	0	11.24
77	1	0	8.	74	1	0	6.35	75	1	0	13.55
78	1	0	10.18	75	1	0	8.6	76	1	0	15.87
79	1	0	12.36	76	1	0	10.84	77	1	0	18.18
80	1	0	14.55	77	1	0	13.09	78	1	0	20.5
81	1	0	16.73	78	1	0	15.34	79	1	0	22.81
82	1	0	18.91	79	1	0	17.59	80	1	0	25.12
83	1	0	21.09	80	1	0	19.83	81	1	0	27.44
84	1	0	23.27	81	1	0	22.08	82	1	0	29.75
85	1	0	25.45	82	1	0	24.33	83	1	0	32.07
86	1	0	27.64	83	1	0	26.58	84	1	0	34.38
87	1	0	29.82	84	1	0	28.83	85	1	0	36.69
88	1	0	32.	85	1	0	31.07	86	1	0	39.01
89	1	0	34.18	86	1	0	33.32	87	1	1	1.32
90	1	0	36.36	87	1	0	35.57	88	1	1	3.64
91	1	0	38.55	88	1	0	37.82	89	1	1	5.95
92	1	1	0.73	89	1	1	0.07	90	1	1	8.26
93	1	1	2.91	90	1	1	2.31	91	1	1	10.58
94	1	1	5.09	91	1	1	4.56	92	1	1	12.89
95	1	1	7.27	92	1	1	6.81	93	1	1	15.21
96	1	1	9.45	93	1	1	9.06	94	1	1	17.52
97	1	1	11.64	94	1	1	11.51	95	1	1	19.83
98	1	1	13.82	95	1	1	13.55	96	1	1	22.15
99	1	1	16.	96	1	1	15.8	97	1	1	24.46
100	1	1	18.18	97	1	1	18.05	98	1	1	26.78
67 by 67	0	3	28.4	98	1	1	20.3	99	1	1	29.09
68	0	3	30.61	99	1	1	22.55	100	1	1	31.4
69	0	3	32.83	100	1	1	24.79	**71** by 71	1	0	6.64
70	0	3	35.04	**69** by 69	0	3	37.39	72	1	0	8.99
71	0	3	37.26	70	0	3	39.67	73	1	0	11.34
72	0	3	39.47	71	1	0	1.95	74	1	0	13.69
73	1	0	1.69	72	1	0	4.23	75	1	0	16.03
74	1	0	3.9	73	1	0	6.51	76	1	0	18.38
75	1	0	6.12	74	1	0	8.79	77	1	0	20.73
76	1	0	8.33	75	1	0	11.07	78	1	0	23.07
77	1	0	10.55	76	1	0	13.36	79	1	0	25.42
78	1	0	12.76	77	1	0	15.64	80	1	0	27.77
79	1	0	14.98	78	1	0	17.92	81	1	0	30.12
80	1	0	17.19	79	1	0	20.2	82	1	0	32.46
81	1	0	19.4	80	1	0	22.48	83	1	0	34.81
82	1	0	21.62	81	1	0	24.76	84	1	0	37.16
83	1	0	23.83	82	1	0	27.04	85	1	0	39.5
84	1	0	26.05	83	1	0	29.32	86	1	1	1.85
85	1	0	28.26	84	1	0	31.6	87	1	1	4.2
86	1	0	30.48	85	1	0	33.88	88	1	1	6.55
87	1	0	32.69	86	1	0	36.17	89	1	1	8.89
88	1	0	34.91	87	1	0	38.45	90	1	1	11.24
89	1	0	37.12	88	1	1	0.73	91	1	1	13.59
90	1	0	39.34	89	1	1	3.01	92	1	1	15.93
91	1	1	1.55	90	1	1	5.29	93	1	1	18.28

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
71 by 94	1	1	20.63	**74** by 74	1	0	21.02	**76** by 87	1	1	18.58
95	1	1	22.98	75	1	0	23.47	88	1	1	21.09
96	1	1	25.32	76	1	0	25.92	89	1	1	23.6
97	1	1	27.67	77	1	0	28.36	90	1	1	26.12
98	1	1	30.02	78	1	0	30.81	91	1	1	28.63
99	1	1	32.36	79	1	0	33.26	92	1	1	31.14
100	1	1	34.71	80	1	0	35.7	93	1	1	33.65
72 by 72	1	0	11.37	81	1	0	38.15	94	1	1	36.17
73	1	0	13.75	82	1	1	0.6	95	1	1	38.68
74	1	0	16.13	83	1	1	3.04	96	1	2	1.19
75	1	0	18.51	84	1	1	5.49	97	1	2	3.7
76	1	0	20.89	85	1	1	7.93	98	1	2	6.21
77	1	0	23.27	86	1	1	10.38	99	1	2	8.73
78	1	0	25.65	87	1	1	12.83	100	1	2	11.24
79	1	0	28.03	88	1	1	15.27	**77** by 77	1	0	36.
80	1	0	30.41	89	1	1	17.72	78	1	0	38.55
81	1	0	32.79	90	1	1	20.17	79	1	1	1.09
82	1	0	35.17	91	1	1	22.61	80	1	1	3.64
83	1	0	37.55	92	1	1	25.06	81	1	1	6.18
84	1	0	39.93	93	1	1	27.5	82	1	1	8.73
85	1	1	2.31	94	1	1	29.95	83	1	1	11.27
86	1	1	4.69	95	1	1	32.4	84	1	1	13.82
87	1	1	7.07	96	1	1	34.84	85	1	1	16.36
88	1	1	9.45	97	1	1	37.29	86	1	1	18.91
89	1	1	11.83	98	1	1	39.74	87	1	1	21.45
90	1	1	14.21	99	1	2	2.18	88	1	1	24.
91	1	1	16.6	100	1	2	4.63	89	1	1	26.55
92	1	1	18.98	**75** by 75	1	0	25.95	90	1	1	29.09
93	1	1	21.36	76	1	0	28.43	91	1	1	31.64
94	1	1	23.74	77	1	0	30.91	92	1	1	34.18
95	1	1	26.12	78	1	0	33.39	93	1	1	36.73
96	1	1	28.5	79	1	0	35.87	94	1	1	39.27
97	1	1	30.88	80	1	0	38.35	95	1	2	1.82
98	1	1	33.26	81	1	1	0.83	96	1	2	4.36
99	1	1	35.64	82	1	1	3.31	97	1	2	6.91
100	1	1	38.02	83	1	1	5.79	98	1	2	9.45
73 by 73	1	0	16.17	84	1	1	8.26	99	1	2	12.
74	1	0	18.58	85	1	1	10.74	100	1	2	14.55
75	1	0	20.99	86	1	1	13.22	**78** by 78	1	1	1.12
76	1	0	23.4	87	1	1	15.7	79	1	1	3.7
77	1	0	25.82	88	1	1	18.18	80	1	1	6.28
78	1	0	28.23	89	1	1	20.66	81	1	1	8.86
79	1	0	30.64	90	1	1	23.14	82	1	1	11.44
80	1	0	33.06	91	1	1	25.62	83	1	1	14.02
81	1	0	35.47	92	1	1	28.1	84	1	1	16.6
82	1	0	37.88	93	1	1	30.58	85	1	1	19.17
83	1	1	0.3	94	1	1	33.06	86	1	1	21.75
84	1	1	2.71	95	1	1	35.54	87	1	1	24.33
85	1	1	5.12	96	1	1	38.02	88	1	1	26.91
86	1	1	7.54	97	1	2	0.5	89	1	1	29.49
87	1	1	9.95	98	1	2	2.98	90	1	1	32.07
88	1	1	12.36	99	1	2	5.45	91	1	1	34.64
89	1	1	14.78	100	1	2	7.93	92	1	1	37.22
90	1	1	17.19	**76** by 76	1	0	30.94	93	1	1	39.8
91	1	1	19.6	77	1	0	33.45	94	1	2	2.38
92	1	1	22.02	78	1	0	35.97	95	1	2	4.96
93	1	1	24.43	79	1	0	38.48	96	1	2	7.54
94	1	1	26.84	80	1	1	0.99	97	1	2	10.12
95	1	1	29.26	81	1	1	3.5	98	1	2	12.69
96	1	1	31.67	82	1	1	6.02	99	1	2	15.27
97	1	1	34.08	83	1	1	8.53	100	1	2	17.85
98	1	1	36.5	84	1	1	11.04	**79** by 79	1	1	6.31
99	1	1	38.91	85	1	1	13.55	80	1	1	8.93
100	1	2	1.32	86	1	1	16.07	81	1	1	11.54

Dimensions.	Statute content.			Dimensions.	Statute content.			Dimensions.	Statute content.		
Yards.	A.	R.	P.	Yards.	A.	R.	P.	Yards.	A.	R.	P.
79 by 82	1	1	14.15	**82** by 86	1	1	33.12	**85** by 99	1	2	38.18
83	1	1	16.76	87	1	1	35.83	100	1	3	0.99
84	1	1	19.37	88	1	1	38.55	**86** by 86	1	2	4.5
85	1	1	21.98	89	1	2	1.26	87	1	2	7.34
86	1	1	24.6	90	1	2	3.97	88	1	2	10.18
87	1	1	27.21	91	1	2	6.68	89	1	2	13.02
88	1	1	29.82	92	1	2	9.39	90	1	2	15.87
89	1	1	32.43	93	1	2	12.1	91	1	2	18.71
90	1	1	35.04	94	1	2	14.81	92	1	2	21.55
91	1	1	37.65	95	1	2	17.52	93	1	2	24.4
92	1	2	0.26	96	1	2	20.23	94	1	2	27.24
93	1	2	2.88	97	1	2	22.94	95	1	2	30.08
94	1	2	5.49	98	1	2	25.65	96	1	2	32.93
95	1	2	8.1	99	1	2	28.36	97	1	2	35.77
96	1	2	10.71	100	1	2	31.07	98	1	2	38.61
97	1	2	13.32	**83** by 83	1	1	27.74	99	1	3	1.45
98	1	2	15.93	84	1	1	30.48	100	1	3	4.3
99	1	2	18.55	85	1	1	33.22	**87** by 87	1	2	10.21
100	1	2	21.16	86	1	1	35.97	88	1	2	13.09
80 by 80	1	1	11.57	87	1	1	38.71	89	1	2	15.97
81	1	1	14.21	88	1	2	1.45	90	1	2	18.84
82	1	1	16.86	89	1	2	4.2	91	1	2	21.72
83	1	1	19.5	90	1	2	6.94	92	1	2	24.6
84	1	1	22.15	91	1	2	9.69	93	1	2	27.47
85	1	1	24.79	92	1	2	12.43	94	1	2	30.35
86	1	1	27.44	93	1	2	15.17	95	1	2	33.22
87	1	1	30.08	94	1	2	17.92	96	1	2	36.1
88	1	1	32.73	95	1	2	20.66	97	1	2	38.98
89	1	1	35.37	96	1	2	23.4	98	1	3	1.85
90	1	1	38.02	97	1	2	26.15	99	1	3	4.73
91	1	2	0.66	98	1	2	28.89	100	1	3	7.6
92	1	2	3.31	99	1	2	31.64	**88** by 88	1	2	16.
93	1	2	5.95	100	1	2	34.38	89	1	2	18.91
94	1	2	8.6	**84** by 84	1	1	33.26	90	1	2	21.82
95	1	2	11.24	85	1	1	36.03	91	1	2	24.73
96	1	2	13.88	86	1	1	38.81	92	1	2	27.64
97	1	2	16.53	87	1	2	1.59	93	1	2	30.55
98	1	2	19.17	88	1	2	4.36	94	1	2	33.45
99	1	2	21.82	89	1	2	7.14	95	1	2	36.36
100	1	2	24.46	90	1	2	9.92	96	1	2	39.27
81 by 81	1	1	16.89	91	1	2	12.69	97	1	3	2.18
82	1	1	19.57	92	1	2	15.47	98	1	3	5.09
83	1	1	22.25	93	1	2	18.25	99	1	3	8.
84	1	1	24.93	94	1	2	21.02	100	1	3	10.91
85	1	1	27.6	95	1	2	23.8	**89** by 89	1	2	21.85
86	1	1	30.28	96	1	2	26.58	90	1	2	24.79
87	1	1	32.96	97	1	2	29.36	91	1	2	27.74
88	1	1	35.64	98	1	2	32.13	92	1	2	30.68
89	1	1	38.31	99	1	2	34.91	93	1	2	33.62
90	1	2	0.99	100	1	2	37.69	94	1	2	36.56
91	1	2	3.67	**85** by 85	1	1	38.84	95	1	2	39.5
92	1	2	6.35	86	1	2	1.65	96	1	3	2.45
93	1	2	9.02	87	1	2	4.46	97	1	3	5.39
94	1	2	11.7	88	1	2	7.27	98	1	3	8.33
95	1	2	14.38	89	1	2	10.08	99	1	3	11.27
96	1	2	17.06	90	1	2	12.89	100	1	3	14.21
97	1	2	19.74	91	1	2	15.7	**90** by 90	1	2	27.77
98	1	2	22.41	92	1	2	18.51	91	1	2	30.74
99	1	2	25.09	93	1	2	21.32	92	1	2	33.72
100	1	2	27.77	94	1	2	24.13	93	1	2	36.69
82 by 82	1	1	22.28	95	1	2	26.94	94	1	2	39.67
83	1	1	24.99	96	1	2	29.75	95	1	3	2.64
84	1	1	27.7	97	1	2	32.56	96	1	3	5.62
85	1	1	30.41	98	1	2	35.37	97	1	3	8.59

Dimensions.	Statute content.	Dimensions.	Statute content.	Dimensions.	Statute content.
Yards.	A. R. P.	Yards.	A. R. P.	Yards.	A. R. P.
90 by 98	1 3 11.57	**92** by 99	1 3 21.09	**95** by 98	1 3 27.77
99	1 3 14.55	100	1 3 24.13	99	1 3 30.91
100	1 3 17.52	**93** by 93	1 3 5.92	100	1 3 34.05
91 by 91	1 2 33.75	94	1 3 8.99	**96** by 96	1 3 24.66
92	1 2 36.76	95	1 3 12.07	97	1 3 27.83
93	1 2 39.77	96	1 3 15.14	98	1 3 31.01
94	1 3 2.78	97	1 3 18.21	99	1 3 34.18
95	1 3 5.79	98	1 3 21.29	100	1 3 37.36
96	1 3 8.79	99	1 3 24.36	**97** by 97	1 3 31.04
97	1 3 11.8	100	1 3 27.44	98	1 3 34.25
98	1 3 14.81	**94** by 94	1 3 12.1	99	1 3 37.45
99	1 3 17.82	95	1 3 15.21	100	2 0 0.66
100	1 3 20.83	96	1 3 18.31	**98** by 98	1 3 37.49
92 by 92	1 2 39.8	97	1 3 21.42	99	2 0 0.73
93	1 3 2.84	98	1 3 24.53	100	2 0 3.97
94	1 3 5.88	99	1 3 27.64	**99** by 99	2 0 4.
95	1 3 8.93	100	1 3 30.74	100	2 0 7.27
96	1 3 11.97	**95** by 95	1 3 18.35	**100** by 100	2 0 10.58
97	1 3 15.01	96	1 3 21.49		
98	1 3 18.05	97	1 3 24.63		

THESE TABLES have been computed by my Assistants, MR. A. R. SOWDON and MR. W. EVE, and the proofs from the press most carefully examined by MR. W. EVE and MR. FRANK HARROW, whose assistance I have much pleasure in acknowledging.

CHAPTER VII.

LAND SURVEYING.

UNLIKE Land Measuring, the Science of Land Surveying, to be practised successfully, requires that the person who uses it should be well educated in the several branches of Arithmetic, Algebra, Logarithms, Trigonometry, and Geometry; and to carry on Surveys of extensive and varied character, several years of previous practice is necessary.

Under the heading of Land Surveying, is properly included every description of Mapping and Levelling, in whatever manner performed.

As great, if not greater improvements have been effected in this particular science within the last few years than in any other, and many costly works have been published, but as I believe, with very few exceptions, those works, while they profess to do everything, contain nothing, comparatively speaking, of the practical methods adopted by skilful surveyors of the present day. The little work in Mr. Weale's Rudimentary Treatises* is written by a practical Surveyor, and contains many very useful remarks, which will, doubtless, conduce to promote its circulation; but with this exception, I am not acquainted with any Treatise exclusively penned by a practical man. They are, for the most part, the production of schoolmasters and other mere theorists; and some of them are but enlarged editions of original works, written previous to the introduction of those improvements into the practice of Surveying of which I have spoken.

Perhaps the greatest stimulant Civil Surveying ever received was, the passing of the Tithe Commutation Act in 1836, under which all titheable lands in England and Wales were required to be surveyed and mapped. In accordance with the provisions of that Act and the new Poor-Law Assessment Act of a previous session, I, in my own personal practice, surveyed and mapped parishes to an aggregate extent of about sixty thousand acres within a period of ten years. It has long been my desire to publish fully the practical knowledge experience has taught me in that and subsequent works; but a want of time, coupled with the very great expense of such a publication, and its usually unprofitable character (at all events to an author) has deterred the intention.

* *Land and Engineering Surveying*. by T. Baker, C.E.

The following Synopsis is intended to contain such information as will afford an insight into the best principles of the science, in character with the nature of the present work.

Sec. 1.—*Parish and Estate Surveying.*

The first step in the practice of Surveying is to learn to chain a line with accuracy and dispatch; the former of which being acquired, the latter will be sure to follow, with practice. An active man who has a good eye is invaluable to a surveyor as a chain-man: such a one is very difficult to be obtained, and is not often to be met with in a purely agricultural district. Many of the most active men being wholly incapable of sticking out a straight line, while on the contrary, men with excellent eyes are frequently too cloddy in their motions to get across a country. A little attention in the selection of a chain-man will amply repay the trouble.

The best way to direct a chain is for the person who follows it to stand perfectly upright behind the arrow which has been left in the ground; his heels touching each other, his toes pointed out on either side of the arrow, and his feet forming something like an angle of 30 degrees with the chain line. His chain-man should also stand erect, and so soon as he is placed nearly in his position, should take care that his heels touch, and that his feet form the reverse position of his director, who is then enabled, by the motion of the thumb of the right-hand in which he holds the handle of the chain, to bring him into an exact line between himself and the fore mark, which, if of good size and well chosen, will then appear to rise directly above the centre of the man's head. The man, if he understand his business, will at the same time discover if any particular object which he may have noticed to have been either in a direct line with the chain, or bearing a relative position therewith in former sets, still occupies the same position, and thus becomes a guarantee that no mistake has been made in the foremark. He will then be careful to tighten the chain so soon as the director has his handle to the arrow; when he has so done, will stick his arrow down between his feet, and will then be ready to proceed on his line when directed. The director of the chain having the handle in his right-hand, will stoop down as soon as his chain-man is in the right direction; and putting his thumb through the bow or eye of the arrow, will cause the handle of the chain to touch the arrow; and seeing that while in that position his chain-man places his arrow properly in the ground, will, as soon as that is accomplished, close his hand without withdrawing his thumb, and in rising will

draw the arrow up with him. Five arrows can in this way be very conveniently carried, their points always sticking out to the right, the obvious consequence of the hand being closed upon them, and the back of the hand being kept in a perfectly horizontal position, otherwise the points will be found to be sticking in the ground when the attempt is made to put the thumb through the eye of the arrow. According to the height of the person directing a chain will be the distance from the arrow at which his feet will require to be placed, so that when he stoops to touch the wire with the handle, the chain may exactly reach the required spot without subsequently requiring to be moved either backwards or forwards: this also is one of those mechanical performances in which practice will produce the greatest proficiency.

The chain-man should carry the arrows in his left hand, the chain in his right, and while walking along should draw one arrow out of the bundle with his right hand in readiness for use at the termination of the chain. He should also pay attention to the length of a chain, so as to judge approximately the point at which he will have to stop, that no sudden jerk may be experienced by the chain (which does it great harm) and that the operation of turning round and getting in line be effected as quickly as possible; to which end he should be instructed to be always on the look out for his back mark, and by moving about to place himself as nearly as he can do in the same relative position with it and the director (who is standing at the last arrow) as he occupied in setting the previous chains. A chain-man's attention should be called to the necessity of observing, as soon as the first chain on a line is set, the position of some one or more objects to serve as a back mark; it will save much loss of valuable time, and no end of trouble, and there are seldom cases when something cannot be noticed, at all events, if not directly in line, so little removed from it that its position can be approximately determined.

Before commencing to chain a line, the director of the chain should stand at the point at which the line commences, and looking at the most distant fore mark, should observe if any remarkable object, a green spot in a field, a gap or a bush in a hedge, a tree, a bough, or a thistle, is directly in his line; if so, he should frequently notice while traversing the line, that his position with reference to it becomes unaltered; and by the exercise of care in this manner, a line 30 or 40 chains in length, may be chained with perfect straightness without any artificial setting out. But if there is no intervening object, and the line is a long one with off-sets, it will be better to direct one or two sticks to be stuck up at inter-

mediate distances, for the best men will sometimes wind a line if they have but a single mark at the end of it to guide them.

Very competent surveyors vary in their practice as to the number of arrows they use. I have had experience in the several methods, both from necessity (caused by the occasional loss of an arrow) and design, and have no hesitation in recommending the number ten as the most practical, surest, and best. The chain-man proceeds with his eleventh chain precisely in the same manner as though he had a handful of arrows, the only difference in his operation being, instead of sticking down that of which he has none left, he lays his handle of the chain on the ground and places his foot upon it, in which position he remains until the ten wires are brought up to him by the director, of whom he takes them, immediately places one in the ground, and then proceeds on his way.

The pointed end of the swivel in the centre of the chain should always determine the end which should go first; if attention is not paid to this, the abrupt angles at the other end of the swivel hang in the bushes in passing through hedges, and frequently meet with other obstructions which jerk and stretch the chain, and which are passed harmless if the other end is driven first.

To ensure expedition, a surveyor's field staff should include a man to draw and another to follow the chain, a boy to carry sticks and make marks and stations; and if the work is very thick, a competent person to measure the offsets, himself keeping the book; if not very close work, he can save the offset man by using the rod himself: the great desideratum being (always assuming the practice is followed for a profit) to keep the chain continually moving.

Throughout the course of every line an infinity of marks should be made at intervals, certainly not exceeding ten chains, and if at five the better. These marks will be found exceedingly useful in determining the position of other lines falling near them, and in the detection of an error, an event which will happen occasionally to the most careful.

This induces a notice of a few of the most fruitful sources of error to young surveyors. First may be mentioned, want of attention to the change of arrows at the end of ten chains; then the omission in long naked lines to make any note in the book of the number of changes as they successively occur; the mistake of the 40 brass mark for 60; the 20 for 80; the confusion of the fore mark with some other object similar, but out of direction; cases in which it is impossible to set an arrow down at the end of the chain that perhaps occurs in the centre of a pond or a deep ditch, in consequence of which several parts of a chain are obliged to be used,

and require to be set to rights when the obstruction is passed; and last, though not of least importance, the too common practice of allowing a chain-man to hold his own handle of the chain to the point which terminates the line, instead of hauling beyond it, by which means the chain is frequently read from the wrong end, or an offset is booked at the wrong place.

The best marks to be made on a line in grass lands are such as can be cut out with a small spade in one of the forms of fig. 136, and if many of them are made in one piece of ground, they should be distinguished from one another, as shewn in the fig., where the different position of the detached diamond, which is entered in the book as marked on the land, readily effects it. In arable land nothing more can be done than driving in a peg; but every fence should be marked, either by a race mark on a quickset or bough, or in any ready way which may present itself. All pale fences should be rased on passing, and every post which may be in line.

The length of the offset rod in most general favour is ten links, but fifteen links will be found preferable; and the one used by me is twenty links. It is made of a straight piece of ground-ash. It has no figures on it; but the links are marked by characteristic colouring; an arrangement which allows either end to be used without chance of error.

In "*sticking out a line*," particular care should be taken that *at least* three (as many more as possible) of the ranging rods or pickets are seen at the time of planting a fresh one; an obvious precaution against a deviation of the line, which the slightest inaccuracy would produce if only two were used. In crossing the sharp apex of a hill great care is also required to preserve the straightness of a line, and in many cases which occur in large surveys, the use of an instrument, if not absolutely indispensable is very desirable. It sometimes happens that a line may be ranged across a series of hills, from apex to apex, and the intermediate spaces across the valleys subsequently managed, but no regular rule can be laid down; generally, the great consideration is, to get some permanent and very prominent back and fore mark, if possible, beyond the limits of the work. As an illustration of this method, in conducting a survey of the parish of Horsell, in Surrey, about two years since, I found the church, in the heart of the village, to occupy a very prominent position on a hill; and I immediately obtained permission to use the tower (a square one) as a station. Upon the top of this I erected a large flag pole, and from that pole laid out a line towards every remarkable object on the

surrounding hills, regardless of where it would terminate, and then connected them by base lines. These lines were all patterns of straightness—houses and farm buildings offered small obstacles with such a mark behind and before; and although it frequently happened that for eight or ten fields we could see neither, no instance occurred in which the end of our line was not proved beyond doubt as being in the same direction in which we started.

A knowledge of the principles of what is technically called "*taking up the details*" of a survey, next claims our attention. This is done by means of what are called "offsets," or short lines measured from any given point on a chain line to an angle or point in a hedge, fence, or building, to fix the position of that point upon the plan. These offsets are measured with the offset rod already spoken of, and are generally taken at right angles with the chain line, simply because that is an angle that may be very approximately determined upon the ground and as readily upon the plan, without the aid of an instrument in either case; short distances only being used. It is not however at variance with sound principles if a sextant or any angular instrument is used, if these offsets are made to take any other angle which special circumstances may require; but then it involves the noting of the angle, and so forth, and occasions an inconvenience and trouble to the surveyor, which he will always avoid if he can. All offsets not specially denoted by any angle are understood to be right angles, whether under a variety of circumstances that may have occurred in the field they are so drawn in the book or not.

There is another species of offsets called "*opposites*," and distinguished from the ordinary offsets by the letters "op" annexed to them. They are such as these: supposing two chain lines A B and A C, (fig. 137,) to pass on either side the house D, and that in chaining those lines the points *a* and *d*, at which the line of the front of the building *b c* would, if produced, intersect, had been noticed; then would the distance *a b* become an "op." at the point *a* on the line A C to the corner of the house D, and the distance *c d* would become an "op" at the point *d* on line A B to the same house D, the position of which, if the points are correctly taken, a proof of which is afforded by measuring *b c*, must be obviously better fixed than by any other method of offsetting.

When the distance between any two points on a given line of fence or building is taken, it is called an "along," and is entered in the book with an "*a*" attached to the figures, thus 24 *a* placed on a line between two points denotes it is 24 along that line from point to point.

The accuracy of an offset depends upon the care with which it is taken; but after all it is generally little more than an approximation to truth, and becomes more and more liable to error as it is increased in length; for it may be measured on the ground with a little inclination from the perpendicular in one direction, and plotted on the paper with an inclination in the opposite direction. Slight inaccuracies may also occur in measuring with the rod; hence, what is of but trifling importance in small operations increases with a significant ratio, and renders it necessary to subscribe a limit to the length of the offset. This limit has been usually fixed by writers on the subject at "one chain;" but that is too much, except for very small scales, and as applied to the scale of 44 feet to an inch, adopted by the General Board of Health for all plans made under the "Public Health Act 1848," totally impracticable. To that scale two lengths of the rod used is quite as long as any offset can be safely taken, and then great care is required to make them plot nicely, as every half link makes a perceptible difference. The length of the offset must therefore be a discretionary point with the surveyor, as ranging from about 30 to 80 or 100 links, according to circumstances; special points and sharp angles being as much as possible fixed by short offsets, while fences running nearly parallel to the chain line in which a departure from the perpendicular will neither affect the length of the offset nor the position of the fence on the paper, may form exceptions for the exercise of a little indulgence.

To illustrate the method of taking up the details, we will consider the fence A *a b c d* B (fig. 138), is to be taken up by the offset line A B. Looking along the fence from the point A, we discover that a bend occurs at the point *a*, and therefore in chaining along the line from A towards B, we carry the point *a* in our mind's eye, and determine when we arrive at the point *a'*, from which the perpendicular *a'a* arises; noting the distances A *a* and *a'a*, we proceed to measure until we arrive at *b'*, where we note the respective distances A *b* and *b'b*, and chain on to *c*; here the chain line touches the fence, and therefore we have only one distance to denote, viz., A *c*; hence, we go on to *d'*, noting in a similar manner the distances A *d'* and *d'd*, and complete our work by entering the length of the line A B. A little consideration and study will convey to the mind of the enquirer the application of this principle to every crooked fence which can possibly occur in a survey. Had there been a fence on the opposite side of the line in fig. 138, as in fig. 139, offsets would have been required, as there shewn; and again, if one line had been insufficient to take up the fence, more must

have been taken, as shewn in Figures 140 and 141; the several ends of the lines being fixed by triangulation, as hereafter to be spoken of.

We now come to the consideration of the method of *laying out the fundamental lines of a survey.* In order to do this effectually, the surveyor must acquaint himself with the boundary of the land to be surveyed, and if he can make one triangle encompass the whole without going too far out of the work, of course that is the best method that can be adopted; because if he can only get the sides of that triangle accurately set out and measured, all other lines within it may be made to depend thereon, and the chances of error are consequently confined to the internal detail thereof, which is easily detected and rectified.

A large triangle, comprising the boundary of an estate, is generally sufficiently proved by the secondary lines that traverse it from side to side in every possible direction; but it is a very great advantage where it can be done to take the angles formed by the several sides of the triangle. This enables the straightness of the sides to be tested by casting the internal angles together and ascertaining if they amount to 180 degrees, as the sum of the internal angles of all triangles should do. It also enables a surveyor to run a proof line from any one of the points of the triangle, so as to fall at a right angle on the opposite side. For instance, let us suppose the angles of the triangle represented in fig. 142 were taken, and that the angle B A C is 38 degrees, we require to let fall the proof line B D, so that the angles B D A and B D C may be each right angles. Taking the angle B A D = 38° and the angle B D A = 90°, we know of course that the angle A B D must be such as will make when cast with the two known angles 180 degrees; hence, in this case, we have to lay off 52 degrees at B as the measure of the angle A B D. If any one of the sides is not straight, the aggregate sum of the observed angles will be either greater or less than 180 degrees, according to the nature of the error. (See fig. 143.) It is hardly to be supposed, with the irregular shapes which boundaries of fields and landed properties assume, that many estates exist which can be enclosed in one triangle, as above stated, although it does sometimes happen, and has within my experience. The estate alluded to is situate on Sunbury Common, between three roads. It is now divided among several owners, but twenty years ago it formed one property, it is represented in fig. 144.

When an estate cannot be entirely encompassed by one triangle, then the desideratum is to enclose as much of it as possible within the triangle, leaving the outskirts to be provided for by secondary

constructions. In the estate represented by fig. 145, having laid out the primary triangle A B C, and the proof line B D, the lines C E, E F, and F G, are severally determined on as necessary, as fundamental lines for that corner of the estate, and to fix their position beyond all doubt with reference to the large triangle the line F G is produced to H, a line is taken from E through G to K, and from C through I to F. To provide for the remaining portion of the estate, a line is run from B to O, from O to M, and from M to N, and then their positions are securely fixed by the lines P L M, B Q M, and L Q O. The great beauty of the method of construction just described is, that if any one of the lines be wrong, the remaining lines are sufficient not only to detect the mistake, but to point out beyond doubt the line in error, and to plot the work accurately without its aid. For example, suppose an error had been contained in either of the lines C E or E F, by plotting the lines C I F, F G H, and E I G K, it would have been apparent at once which was in error, as the other would scale the measured length.

It may be as well to observe, that the constructions herein recommended for estates or blocks of land containing many enclosures, apply equally to single fields of similar proportions, examples of which our space will not admit.

When the limits of the estate to be surveyed assume other forms than those of a triangle, it is generally desirable to divide it into two principal triangles, and provide for the outskirts as most expedient. Fig. 146 is an illustration of my meaning. Here A B C and C D A are the two principal triangles, and the accuracy of the two opposite points B and D is securely tested by the proof line B E D; then by using E as a common point, and laying out E F G, H I E, A G, G H, and H D, A E G becomes a triangle with A F as a proof line; E G H a triangle with F I a proof line; and E H D is a triangle with D I as a proof line; while the lines A G, G H, and H D, severally act as proofs to each other and the whole work.

Sufficient having been said to enunciate a principle so far as theory is concerned, it is now proposed to see by a reference to an instance of actual practice, how far this principle can be carried out in practice; for it must be remembered, that in all professions, mere theories, when attempted to be put in practice, are assailed by an infinity of difficulties. Hence, it is totally impossible to prescribe a rule from which no deviation shall be made; the only practical mode is to point out correct tenets, and require as close an approximation thereto as possible.

Plate 5 represents a reduced plan of the parish of Sunbury, surveyed by me about five years since. Several difficulties presented themselves during the laying out of the fundamental lines, of which the close proximity of the River Thames to the village, on the south side of the parish, the number of houses and gardens* scattered about its area, and the very flat nature of the country, formed some of the most prominent. Advantage was first of all taken of the straight piece of road from F to M, and a line ranged down it to A; a second line was then laid out from B to R, escaping as much as possible of the village of Sunbury, but encountering a great portion of the Thames and the tributary streams; a third line was then laid out from R to M, avoiding the villages of Halliford and Charlton, but extending some distance beyond the parish to meet the main line. These three lines formed the fundamental triangle B M R.

The next step was to lay out the proof line R I, about which the only difficulty encountered was at Y. A line was then found practicable from D to W, and at W another line was laid off to fall on the base at right angles at H. A line down the straight road from X through Y to P, completed the principal lines within the large triangle. Lines were then started from R and O, and from their interception at the point *c*, a tie-line was laid out so as to fall at right angles on the base of the triangle at Q. From Q a line was laid out through *a* to *l*, and from Q through *f* and *h* to *i*; *l* O and *l b* being joined the triangles R O *c* and O *b l* became fundamental triangles, well and securely fixed and proved. The small triangle *d e k*, with the lines *k h* and *i g* completed the boundary on the south-west. The triangle T *t* B, with proof lines *t* V and *s* U, and the triangle S *n* R, with lines R M Q, *n o*, *o p*, *n p*, *p q*, *q r*, *r* S, and *r* T (some of which were obliged to be calculated) completed the fundamental lines for the survey of the boundary on the river side; and the triangles A C *u*, C G *w*, G K 3, G 3 *w*, *w* C *u*; with proof lines C *v*; E *x*; F *y*; F 1; *z* 5; 1, 4, 9; 2, 3; and tie and secondary lines 6, 7; 7, 5; 7, 8; 8, 9; 9, 3; 10, 12: and 11, 12, 13 formed all the lines necessary for the triangulation of the parish.

Upon examination, theory might suggest that the triangles to the north of the line A M, should have been fewer in number, and that at all events the line between points *u* and 3 should have been one continuous one; but the local difficulties intervening would have caused a far greater loss of time than any advantage gained

* The houses and gardens are not shewn in detail on the plan owing to the diminutive size of the scale; it has been thought better to block in the sites built upon.

would justify, and therefore the attention was chiefly directed to the formation of a series of triangles, the sides of which would check one another, and be useful as offset lines, in the which we were very successful. It was not deemed expedient to extend *c* Q into the large triangle, the safety of the triangle R *o* C being perfectly secure without it. The lines in the south corner are such as it were possible to obtain; the theodolite being used in all cases where it became necessary to compute the sides of triangles by means of the contained angles. On the whole, the triangulation of this parish is offered as a good practical illustration of the best principles of surveying, carried out without the smallest view to the purposes to which it is now about to be applied; executed, moreover, to produce professional remuneration under the influence of a very bad bargain; and now selected by chance from a number of others equally good, but with less convenient dimensions for the size of our intended work.

Note.—It should be here stated that the *lines*, and not the *stations*, were all numbered in the actual survey. The lettering has been adopted in the plate as offering greater facility of reference.

Having laid out the fundamental lines of a survey, and chained them, the next process requiring attention is what is technically termed "*filling in;*" that is, laying out, and chaining such a number of internal or secondary lines, as may be required, with the offsets upon them, to take up all the fences, houses, buildings, and other features upon the land. Here it must be observed, that the lines taken for this purpose should be what are called "through lines," that is, lines running from any one already fixed line to another line already fixed, so that no distortion of the internal features of the survey, with reference to the external ones can take place. It is not imperatively necessary to the accuracy of the map that these lines are to follow consecutively from one fixed line to another; they may be taken in this way: Let A B, B C, and C A (fig. 147) be the lines of a triangle, already fixed; and a line is required from D to E to take up the neighbouring fence, which at the point E turns to the right. A line is then run from F, crossing E to G, where the fence again deviates its course; and lastly, the line from H, through G to I, completes the filling in of the fence. This is manifestly as correct an operation as though the order of the lines had been reversed (as they will be when they come to be plotted), and H I had been first chained, then G F, and then E D, and equally so as though the line D E had been extended to *e*, that a line had then been carried from E to *f*, and then from G to *i*. The position and direc-

tion of these secondary lines entirely depend upon local circumstances; it is often more expeditious to run two or three lines on the ground, than encounter the local difficulties of laying out one line which would look best upon paper. It is desirable that as many lines as possible should proceed from one station, by reason of the excellent check they become to each other.

I will here notice a few of the methods by which obstructions in the admeasurement of chain lines may be overcome; but it must not for a moment be understood that the plans here suggested are the only efficient ones; on the contrary, an infinite number will present themselves to the mathematician, who will of course adopt that one that may be best suited to the special circumstances for which some expedient is required.

In figure 148 the chain line A B crosses a river, and it is to be premised that the surveyor has no instrument for taking angles with him, he is therefore desirous of getting the inaccessible distance *c d*, in the readiest manner possible. Let the points *a c* represent the extremities of the last perfect chain before arriving at the river, and let *b* be a mark at the centre link of that chain, then let one handle of the chain be held at *a*, and the other at *b*; and by laying hold of the centre of the chain, let the point *f* of the equilateral triangle *a b f* be marked: in a similar manner set out the triangle *b c e*, then will *f e* = *a b* or *b c* = 50 links; let the lines *d e* and *b f* be made to intersect in *g*; and let the distance *f g* be accurately measured in links, and tenths of links by reason of its shortness; then say as the side *f g* of the triangle *f g e* is to the side *f e*, so is the side *e c* of the similar triangle *c d e* to the required side *c d*; for example, let *f g* = 22·6 links; then *f g* = 22·6 : *f e* = 50 : : *e c* = 50 : *c d* = 110 links.

Suppose A B C D, fig. 149, to be the site of a house crossed by the chain line E F G H, which has been previously laid out, either from high ground or by means of good back and fore marks. Measure the distance F D, and set off the same from D to I: in like manner set off C K equal to C G, then will the distance I K equal the required distance F G. Had F D and G C been equal, the line would have crossed the house at right angles, and the width D C would consequently have been equal to the required distance.

Fig. 150 represents a house crossed by the chain line E F G H in a different manner. In this case make D I equal F D, and then because the triangles G D I and F D G are similar and equal, the side G I will be equal to the required side G F. Rectangular hay and corn ricks are generally so nearly right angled

as to admit of this process with sufficient approximation to truth.

If the obstruction is a pond, lay off *a b* (Fig. 151) and *c d*, each equal 50 links on the chain line on either side of the pond; construct the equilateral triangles *a b e*, *a b f*, *c d g*, and *c d h*, by holding the handles of the chain at the points *a b* and *c d*, and marking the points *e f g h*, with the centre of the chain in manner described in the first example; produce *a e*, and *g d* to *k*, and *a f* and *d h* to *i*; then because all the triangles are similar and equilateral the sides *a k*, *k d*, *d i*, and *i a*, are all similar to the required side *a d*. If the pond is small the operations need only be carried on on one side of it, which even then affords a check upon the accuracy of the work, inasmuch as *a k* and *k d* should exactly correspond; but if the equilateral triangles, whose sides are 50 links are very disproportioned to the required side; it is better to repeat the work on both sides, and average the length of the four sides (supposing they do not quite agree) for the length of the required side.

If the surveyor had with him, as every surveyor should have when filling in a survey, a pocket sextant, he would have set out the angles *k a d*, *k d a*, *i a d*, *i d a*, each equal 60 degrees with the sextant.

Some surveyors, in matters of this kind, lay off the angle *d a k* = 60 degrees, and then walking along the line *a k* lay off the angle *a k d* therefrom, also equal 60 degrees. This practice is open to grave objection—for if the slightest inaccuracy is committed in laying off the first angle, it is not only repeated but in all probability increased in the second; whereas in the plan herein recommended, each angle depends solely upon the base line.

One great advantage in the use of a sextant over the chain only, for purposes of this kind, is, that the operations are not required to be of quite such large dimensions, and consequently the liability to error is proportionately diminished; for instance, in the example we have quoted the angles might have been taken at *b* and *c*, the equilateral triangle confined to the actual unknown distance *b c*, and the lines to be measured been reduced to *b l*, *l c*, *c m*, and *m b*.

If an instrument is at hand, when the obstruction of a river (or any other feature) impedes the admeasurement of a line, it is easily overcome in this way—let A and B (fig. 152) be known points in the chain line already measured, and noted in the field book in ordinary course. At B erect a perpendicular, upon which at any point D observe the angle A D B; lay off the angle B D C equal

thereto; then because the triangles A B D and B C D are similar and equal; the unknown base B C equals the known base A B.

The method of keeping a Field Book is varied by different surveyors to a great extent; but in the course of my practice I have made a trial of most methods, and think I may safely challenge all others to a comparison with the one used by myself which is herein recommended.

Fig. 153 illustrates one page of this Field Book, and Fig. 154 the lines therein referred to. —— 13, at the foot of the column, signifies that *line* 13 is the one referred to by the notes. 1636—12, placed at the foot of the page, on the left hand, represents that line 13 starts from the point denoted by the admeasurement 1636, on line 12; and the position of those figures illustrates approximately the relative positions of the two lines. 1290—11, on the right hand side of the page, denotes the point to which line 13 proceeds, and again illustrates, by the position of the figures, the relative positions of the lines 13 and 11. The theodolite bearing is entered to shew the mode of doing it. The correct bearing of the line is entered at top, the opposite bearing beneath it. The offsets to the neighbouring fence speak for themselves: at zero it is two links to the right of the chain line; at 210, on the line, it is twelve to the right; at 280, the line crosses it; at 430, it is 16 to the left; at 520, 10 to the left; at 680, the line crosses it again; and at the same point on the line, it is 59, opposite to the corner of the house, the dimensions of which are given; but to positionise which an op. on another line is required: at 730 another fence, running to the corner of the house is crossed, at 19 *a*, or 19 along which the first fence terminates: at 1050 a point is crossed, which represents zero on line 6 (or 0—6), the position of which line is also relatively shewn: at 1115, the line is opposite the straight portion of another fence, to which is noted an op. of 230: at 1136 it crosses that fence wihch proceeds 3 *a*, and then turns; and at 1250 the line terminates.

If the actual starting point of line 13 had not been known when 12 was measured, so that when 13 was chained, it had become necessary to measure from any given known point on 12 to ascertain such starting point, such distance would have to be expressed in the Field Book, and added to or subtracted from the given point, as the case might be. Fig. 155 illustrates this: 1600—12 is the known point, beyond which 36 links had to be measured to the starting point of—13, and being measured beyond the known point on the given line had to be added thereto. 1350—11 is the nearest known point to which the line proceeds; and falling on

that line between the known point and zero the remeasured distance 60 had to be subtracted from the known quantities, leaving 1290 as the point of junction. The point to which a line proceeds cannot generally be filled in until the line is measured.

By a strict observance to this mode of entering the field notes, and trusting nothing whatever to memory, it becomes as easy to plot the work ten years subsequent to the survey as at the time. I surveyed in or about the year 1842 a parish containing upwards of fourteen thousand acres, and did not lay down a line of it until the work was completed, and I had returned to my office—a circumstance necessitated by the impossibility of getting a room sufficiently large for the map (which was eighteen feet by twelve feet) within the parish surveyed. And as a further proof of the excellence of this kind of Field Book—requiring very recently a replot of this very survey, I placed the Field Books in the hands of two of my pupils, who produced, notwithstanding the circumstances that they had never seen the parish, and knew nothing of the survey, as good a map as my own plot; indeed the operation of plotting from such a Field Book is perfectly mechanical

Sect. II.—*Trigonometrical Surveying.*

In very extensive surveys, such as the Survey of the United Kingdom, now being carried on by the scientific branch of the Ordnance Corps, or (to illustrate a case within my practice) the Survey of the Island of Guernsey, which I am conducting, the methods previously described would not be at all applicable. It would neither be possible to lay out the lines of construction, nor to measure them with a sufficient degree of accuracy. It therefore becomes necessary to adopt some more certain mode of operation by an extended system of triangulation, on the data of one very correctly measured base, and the sides calculated therefrom, and the angles trigged at the vertices of the respective triangles.

In such a system the first attention must be turned to the selection of the base, which should be as long as it possibly can be, in proportion to the extent of the country, and should be situate in a level plain, from either end of which some suitable trigonometrical points can be seen. In the Survey of the Island of Guernsey the base line was chosen in a straight level road.

In cases requiring more than ordinary accuracy, glass, deal, and platinum rods have been used, laid in a level trough purposely erected for the occasion, and brought into contact by the most deli-

cate and careful operations; but for all ordinary purposes, a careful admeasurement by the chain, taken twice in contrary directions, will produce results, the mean of which may be very safely taken as the correct length of the base.

I have said that the base should be measured in a level plain, but I do not intend to imply that no other will do. So that the site chosen for the base does not contain irregularities and undulations of surface, a gentle fall in either direction can obviously cause no other inconvenience than to require the base to be levelled, and from the hypothenusally measured base, and its perpendicular height at one end above the other, the true horizontal base can be readily obtained by any of the Rules of Right Angled Triangles. A C (fig. 103,) being the line measured; A B being the base whose length is required; B C the ascertained height of C above A: or the angle of elevation or depression can be taken with the theodolite from each end of the base, and the calculation will resolve itself into the case of a right angled triangle, in which the hypothenuse and the angles are given to find the base. But the base so found evidently requires some further reduction to render it mathematically correct, according to the degree of elevation at which it is situated above the level of the sea.

The annexed figure will serve to illustrate the nature of this reduction.



a b is the level of the sea, or an arc of the earth's circumference. A B is the reduced level base or a parallel arc, the distance between which is the height above the level of the sea, to which the base has already been reduced.

Now, the length of the arc A B being known, though obviously longer than it should be, at the level of the sea, and the radius of the earth *a* C being assumed as 21,008,000 feet; it is evident that by ascertaining the height of *a* above A the correct length of *a b* may be ascertained; from which as a base, we can calculate the sides of a number of triangles, and from the sides of these triangles, forming so many fresh bases, can safely determine other trigonometrical points, until the whole country to be surveyed is covered with a net work of triangles, which can be correctly delineated upon paper in their true geographical positions.

The following is the formulæ for making this correction:—

From the sum of the log of the altitude A *a*, and the log of the

base A B, subtract the log of the sum of the radius and altitude (a C + A a) and the remainder will be the log of a number of feet, (all the dimensions being taken in feet) to be subtracted from the base A B, to produce the true base a b.

This correction will not be required in ordinary surveys, unless the base measured is at great elevation.

It sometimes happens that the length of a base, or distance between two points eminently qualified as stations to form the extremities of a base, cannot be entirely ascertained by actual admeasurement. The base used for the Ordnance Survey of Ireland was lengthened two miles by calculation beyond the measured distance. I will shew how this can be done, and at the same time be made to test the accuracy of the measured base.

Let A and B (fig. 156,) be two elevated positions, which it is desirable to constitute extremities to the base, and let it be possible to ascertain by admeasurement the length of the line C D E.

First: the line between A and B is correctly staked out by the theodolite or transit instrument, and permanent marks are made at C D E F and G.

Secondly, the line is measured from C to D, and from D to E; and lastly, the following angles are taken:—

At A. F A B and B A G.
At C. A C F; F C B; B C G; and G C A.
At D. A D F; F D B; B D G; and G D A.
At E. A E F; F E B; B E G; and G E A.
At B. A B F; and A B G.
At F. A F C; C F D; D F E; and E F B.
And at G. A G C; C G D; D G E; and E G B.

Now by calculation we have first the triangle C D F, in which are given the base C D, and all the angles, to find the sides C F and D F.

Secondly, the triangle D E F; given the base D E, and all the angles, to find the sides D F and F E.

Thirdly, the triangle C E F; given the base C E, and all the angles, to find the sides C F and E F.

Now the side D F being common to the first and second triangles, if the admeasurement of the base and angles have been correctly taken, the result in each case should correspond.

And the side C F being common to the first and third triangles, and the side E F to the second and third, the results of the calculations should also correspond, and if they do the admeasurement of the two sections of the base C E is proved to be correct.

The same operation takes place on the opposite side of the base with the several triangles C D G; D E G; and C E G.

And thus we obtain lots of data for the calculation of the perfect base A B.

First, we have the triangle C F A, with base C F, and all the angles known, to find A C.

Secondly—The triangle D F A, with base D F, and all the angles, to find A D.

Thirdly—The triangle E F A, with base E F, and all the angles, to find E A.

Fourthly—The triangle E F B, with base E F, and all the angles, to find E B.

And fifthly—The triangle A F B, with base A F, and all the angles, to find A B.

It will be obvious that the calculations and tests can be carried on through several other triangles, on the same side of the base, and a corresponding number on the opposite side; but sufficient has been said to elucidate the principle, and if A D, as found in the second triangle, is equal to the measured length C D, plus A C, as found in the first triangle; and A E, as found in the third triangle, is equal to the measured length C E, plus A C, there can be no doubt as to the accuracy of either A C; C D; or D E. And if the length A B, as found by the fifth triangle, is equal to E B, as found by the fourth, plus A C, plus C D, plus D E, there is sufficient proof of the accuracy of the whole base without reference to other triangles.

The best triangles in the example before us, from which to compute the base, would have been A D F and A D G for the length A D; and D F B, and D G B for the length D B, the sides D F and D G being taken as the mean result of the calculations of the triangles C D F and C D G, and D E F and D E G.

Those who would pursue the subject of bases, beyond these remarks, will find the accounts of the admeasurement of the base lines for the Ordnance Surveys of England and Ireland very interesting. The account of the former operation was published in 1801; and of the latter very recently by Captain Yolland, Royal Engineers.

Detailed accounts of the methods adopted at various times upon the Continent may be found in many standard works—"*Recueil des Observations Géodesiques, par Biot et Arago.*" "*Puissant, Traité de Géodesie.*" "*Base du Système Métrique Decimal;*" and the works of Cassini, Colonel Lampton, &c.

Triangulation.

The second process in a trigonometrical survey is to select a number of conspicuous stations on the highest hills as trigonometrical points, which may either consist of prominent objects such as churches, windmills, towers, and trees, or they may be artificial erections of poles, flag staves, &c. ; the latter possessing the advantage, if the points are intended as theodolite stations, from which to trig other angles, inasmuch as they can be moved to allow the theodolite to be placed over the exact point; but the former are preferable as the stations of scondary triangles, in which it is not considered necessary to trig the third angle. The nearer the triangles are equilateral the less will be the error produced by any fault in taking the angles; and as the base is generally shorter than it is desirable to retain the sides of the principal triangles, they should be enlarged gradually in the following manner, until they attain a length in proportion to the nature of the work and the power of the instruments employed.

Fig. 157 is an illustration. A B is the base from which the several sides of the triangles A B D and A B C are computed. From B D and B C, and the contained angle, we obtain C D, as well as from A D and A C, and the contained angles. The mean of these results is taken as a new base for the triangles C D E and C D F, and in like manner E F is obtained. From E F we proceed to find G H, which has now acquired a length sufficient to take a place as a side of one of the main triangles G H I. Upon H I is built I K, and so the work proceeds.

It is always desirable, but of course not necessary, to take all the angles of each triangle; therefore, while the theodolite is in use at any station, all objects that can be intersected should be trigged; they will be found of infinite service in "filling in," and can never be more accurately fixed in position.

Fig. 158 will represent my meaning. A B C and A B D are two triangles, and A B C D are stations, at which the theodolite will be placed for the angles of those triangles. E F G H I K and L are objects visible from two, and some of them from three, of these stations, which are readily fixed in position by arranging them in triangles and taking the angles. Where objects are thus taken from three stations, the distances obtained become a check upon each other.

It frequently happens that the objects best adapted to form points in a triangle are inaccessible, and the theodolite cannot be placed over the centre of the station. It then becomes necessary

"to reduce the angles taken to the centre." Cases of this nature are of three kinds:—First, when the nearest point at which the theodolite can be placed is within the triangle; secondly, when it is without; and thirdly, when it is on one of the sides of the triangle.

Fig. 159 represents the first case. A B C is the triangle, A is the angle required, and D is the nearest point at which it can be approached by the instrument. Measure A D, and take the angle B D A, B D C, and C D A.

Now the angle B D C = the < B A C + < A B D + A C D. Suppose A B, whose length is known, to be the base of the triangle A B C. Then in the triangle A B D we have the sides A B and A D and < A D B to find *the remaining angles*, and the side B D. Deduct the angle A B D from A B C, and we have in the triangle B C D the side B D, and the angles D B C and B D C to find the side D C. And lastly, in the triangle C D A we have the sides A D and D C, and the contained angle to find the remaining angles.

From the angle B D C subtract the angle A B D, plus A C D, and the remainder is the angle B A C, which should also equal the angle B A D, plus D A C.

Case 2 is illustrated by Fig. 160. A B C is again the triangle, of which A B is the base. D is the theodolite station. The angle B E C equals the angle B D C plus the angle D B A; and the angle B E C equals the angle B A C plus the angle E C A. Hence we must find the angles D B A, B E C, and E C A, and from these the angle B A C is attainable.

Case 3 is when the position of the theodolite is upon one of the sides of the triangle, which is the most simple case of the three.

The distance A D (fig. 161) being measured, the remaining distance of the base is known; and the angle B D C being equal to the angle B A C plus the angle A C D, we have only to find the latter angle, and subtract it from B D C, and it will give the angle B A C required.

It is not always possible to ascertain A D, or the distance of the theodolite from the centre of the station by actual admeasurement; in such cases a short base must be measured from the theodolite in any direction, and the distance found by a small triangle D E A, (fig. 162.)

If the triangles and the instruments made use of are very large, a correction for spherical excess becomes necessary; but in smaller instruments this correction is too minute to be noticed, in comparison with the unavoidably greater errors of observation to which they are subject.

In the conduct of a trigonometrical survey, it not unfre-

quently becomes necessary to visit the same theodolite station a number of times, sometimes after the lapse of a considerable interval; and although every care may have been taken to mark the station well, it may from some cause or other be lost; hence it is desirable that a ready and a certain method of finding a lost station should be known to the surveyor.

Let A B C and D, (fig. 163,) be trigonometrical points, whose distances from each other have been previously determined. Let A be the lost station, and B C and D conspicuous objects.

Set up the theodolite as near the point A as can be surmised. In the figure this point is represented by E, but it is necessary to observe that the distance from E to A is there much greater in proportion to the other sides of the triangles than it should ever be practised: it was impossible to render the figure clear and distinct without making this so.

At E take the angles B E C and C E D, which being larger than the original angles B A C and C A D, it is evident the point is within the circumscribing circles of those triangles. Had our angles been smaller than the original, the point would have been without the circumscribing circles. Now, consider the angle A of the triangle A B C to be altered to the value of the angle B E C, and that the other angle diminished thereby is the angle C. With B C as a base, and these angles compute the side B F of the triangle B F C, subtract B F from A, produce B E, and make E G equal to F A, and at G plant a picket. Again, consider the angle A as of the value of B E C, and that the angle B is diminished in consequence, find C H and H A, produce C E to I, making E I equal to H A.

In similar manner treat the angles of the other triangle C D A, and find A K and A M; produce C E to L; making E L equal A K; produce D E to N, making E N equal A M. The intersection of the lines G I and L N, will be the lost station, provided all the observations and calculations have been taken with sufficient accuracy. To verify it the theodolite must now be placed on the point supposed to be the point A, and the angles between B C and C D retaken; if these read the same as the original the point is right, but if not, it must be used as a second trial station, and the operation repeated. It is better, when possible, to let the operation embrace three previous triangles, because if any mistake is made in calculation, the three lines will not intersect each other at a point, but will leave a small triangle between them, the centre of which should be taken as the second trial station. On the other hand, if they do intersect each other at the same point, it affords strong proof of the accuracy of the whole work.

If the first trial station falls without the circumscribing circle of the original triangle, the operation is precisely the same in every particular, excepting that the differences of distance between the sides found, and the original sides are set off from the trial station E towards the points B C and D, instead of producing those lines, as in the former case.

It often becomes desirable to fix the position of a station by means of the angles taken at that station only. This may always be done if three objects are visible, whose distances from each other, forming three sides of a triangle, are known.

Let A B C, (fig. 164,) be three objects, whose several distances from each other (A B, A C, and B C) are known.

Let D be the point whose position it is required to fix.

The angles A D C and C D B are taken.

Now, by inspection of the diagram, it is obvious that if about the points A B D we circumscribe a circle, the angle E A B must equal the angle E D B (being in the same segment of a circle, Euclid B 3, Prop. 21), and the angle A B E equal the < A D E. Therefore in the triangle A B E we have the base A B, and all the angles to find the sides A E and B E.

In the triangle A B C, the angles are either known or can be ascertained by calculation of the sides.

From the angle C A B subtract the < E A B, the remainder is the < C A E, from which, and the two sides A C and A E find the < A C E = A C D. Then with the base A C, and angles A C D and A D C, find the sides A D and C D.

Again, from the angle A B C, deduct the < A B E, the remainder is the < E B C, from which, and the two sides B E and B C, find the angle B C E = B C D. Then with the base B C, and angles B C D and B D C, find B D and C D. C D being common to both calculations, proves the latter part of the work.

But the vertex C of the triangle A B C will sometimes be turned towards the place of observation D, as in fig. 165.

Very little difference takes place in the arrangement of the calculation. A B, A C and B C are known, and consequently their contained angles. The angle A D C = the < A D E = the < A B E, and the < C D B = the < E D B = the angle E A B are also known.

Therefore in the triangle A B E, the base A B and angles A B E and B A E are given to find the sides A E and B E.

In the triangle A C E are given the sides A C and A E, and the angle C A E = E A B plus B A C to find the angle A C E.

Now, the angle A C E is the external angle of the triangle

A C D, and (Euc. B 1, Prop. 32) equal to the two internal oppoposite angles C A D and C D A.

Hence, if from the angle A C E be taken the angle C D A, the remainder is the < C A D, and in the triangle A C D we have the base A C, and all the angles given to find the other sides C D and A D.

In like manner is found the < B C E in the triangle B C E; and the < B C E being known, <* C D B and B C D are also known; and the sides B D and C D are found from the base B C.

The three known objects A B and C may possibly fall in one straight line, such as three stations of a base line.

Fig. 166 represents this case. Now, the < A D C = the < A D E = the < A B E is known. And the < C D B = the < E D B = the < E A B is also known.

Therefore, in the triangle A B E, the base A B, and all the angles are known to find the sides A E and B E.

Next, the sides A C and A E and the contained < being known, the < A C E is determined. And the < A C E being the external < of the triangle A C D, the angles of that triangle, and the base A C, are given to find the sides A D and C D.

And again, B C and B E, with the contained < being known, the < B C E is obtainable; and the < B C E being the external < of the triangle B C D, we have all the angles, and base B C of that triangle given to find the sides C D and B D.

But the point of observation D will sometimes fall within the triangle A B C.

Let fig. 167 illustrate this case.

Now, the < A D C is known, and the < A D E being the supplement of < A D C is also known; and the < A B E standing within the same segment, is equal to < B D E; < C D B is known; and < E D B is the supplement of < C D B, and <* B D E and B A E being within the same segment, are equal.

Therefore, in the triangle A B E, the base A B and all the angles are given, and the sides A E and B E can be thus obtained.

The angles within the known triangle A B C are also given or obtainable.

Next, in the triangle C A E, the sides A C and A E are known and the contained angle (equal the < C A B plus < B A E) to find the < A C E = < A C D.

In the triangle A C D, the base A C and all the angles are given to find the sides A D and C D.

Again, in the triangle C B E, the sides B C and B E and the contained angle (equal the < A B C + < A B E) are given to find the < B C E = < B C D.

Lastly, in the triangle B C D, the base B C and all the angles are given to find the sides B D and C D.

It is sometimes desirable to fix the positions of two new stations by means of observations, taken at those two stations with reference to two old stations, whose distances from each other are known.

Let A and B, (fig. 168,) represent the old stations, and C and D the new; it is required to know the distances A C, B C, A D, B D, and C D.

At C take the angles A C B and B C D, and at D take the $<$ C D A and A D B.

To compute the triangles assume C D, equal any convenient distance G F.

Then with base G F and angles A G F = A C D, and A F G = A D C, find A F and A G.

In like manner find E F and E G.

Then with the sides A G and the contained $<$ A G E = $<$ A C B, find A E.

Again (as a proof) with the sides A F and E F, and $<$ A F E = $<$ A D B, find A E.

Then, As A B : A E : : A G : A C.
As A B : A E : : E G : B C.
As A B : A E : : A F : A D.
As A B : A E : : E F : B D.
As A B : A E : : G F : C D.

Filling in.

The interior details of a Trigonometrical Survey can be "filled in," in the same manner as previously described for the filling in of a parish or estate survey, or by a traverse. The distances from one trigonometrical point to another can be chained, and between these lines other lines can be laid out and measured, as often as circumstances may require. Fig. 169 will illustrate this method.

Sect. III.—*Traverse Surveying*

Is a method of surveying by means of a chain and theodolite, or other angular instrument (according to the degree of accuracy required), which is frequently resorted to in filling in the roads on a trigonometrical survey, where it is sometimes impossible to adopt the more accurate, though less expeditious method of chaining between every trigged station, and filling up the interior by through lines. My survey of Guernsey is conducted in this way.

The objects chosen to form the vertices of the principal triangles (consisting of twelve windmills, seven church steeples, several martello and other towers, batteries, signal masts, &c.) occupy for the most part such inaccessible positions, and the country generally is so irregular and broken as to render any attempt to chain some of the sides of the triangles ridiculously futile.

The "traverse system," while it possesses the advantage noticed above, also possesses another advantage with reference to the Guernsey Survey, inasmuch as it enables the survey of the numerous roads with which the Island is covered to be proceeded with during the fine weather of the summer months, which would have been entirely prevented by the crops had the "right line" system of filling in been exclusively adopted.

The little blocks between the roads are afterwards filled in by a system of through lines from road to road, in the same manner as though the roads bounded a right line triangle.

Fig. 170 represents the mode of carrying on a traverse survey.

A B C are the points of a triangle, whose positions have been computed.

From A, line 1, proceeds by the nearest accessible route into the road; lines 2, 3, 4, &c., continue along the road until the end of line 9, which has arrived opposite the station B to which line 10 is directed. Lines 11, 12, 13, 14, 15, again proceed in the road; and 16 starting from station C, and crossing the end of line 15, continues the traverse along the road, and closes by line 20 falling upon the end of line 1 and beginning of line 2. Line 21 commences at a point on line 7, and proceeds to traverse the intersecting road, which is completed by line 26 falling upon line 14.

The angles are now taken, and an opportunity is afforded, without much (if any) loss of time, for rechaining the lines without the offsets, as a proof of their accuracy.

The theodolite being placed at station A, is adjusted and set to zero, and the telescope is directed to the magnetic meridian, or in other words, the entire head of the instrument is turned round until the marked end of the needle points to zero in the compass box—the other or south end pointing to 180°.

The lower plate is then clamped, and the upper plate unclamped, and the telescope is directed at station B: the bearing of which is read off and entered; the upper plate is again unclamped, and the bearing of line 1 is taken and entered.

The instrument is now taken to the beginning of line 2, and there set up and adjusted. The telescope is turned upon line 1, and since the upper plate has not been touched since the bearing

of line 1 was taken, it still remains clamped at that bearing (but this should always be verified by examination, as the operation of carrying the instrument from one station to another will sometimes shake it a little out of place if the clamp screws are not very securely fastened), and the screws may also be inadvertently touched in the process of levelling the instrument.

It being obvious that the telescope and limb being now in a position exactly parallel to the one they occupied at the station A, excepting that they have been reversed 180°, the needle should, when set free, settle down at the same bearing as above, saving that the reading which was before at the marked or north end is now at the south end, consequent upon the reversion of the instrument. Clamp the limb, or lower plate, and unclamp the upper one; and as this is the point at which line 20 closes the work, direct the telescope upon that line, before the bearing of line 2 is taken, so that the last reading at the station may be the bearing of the line from which the next line of the series proceeds.

Here I should observe, that the compass or real bearing of the line, when the instrument follows the work in the same direction as the lines were measured, being always the bearing indicated by the *marked* end of the needle (as taken at the beginning of any line), it should always be written uppermost; the other or "opposite" bearing, which differs from the real bearing exactly 180°, being placed below. Strict attention to this will serve to denote at any future time the direction of the lines; and as line 20 is now taken at the end instead of the beginning, the bearing indicated by the north end of the needle will be the "opposite" bearing of the line when the instrument is placed in true position with respect to it, and it must be so entered accordingly.

The bearing of line 2 being taken, the instrument is moved to line 3, and in like manner the work proceeds regularly until it arrives at line 10, when the instrument being placed on station B, and directed at A, the bearing of A B should read the same (reversed) as it read at A; if it does, the angles have all been correctly taken; if not, there is an error which must be detected before greater mischief is done. Assuming the work to be correct the bearing of △ C is taken from B, and also the bearing of the station forming the end of line 11, and the beginning of 12, to which the instrument is next removed, and being adjusted and levelled, and directed at the back bearing of △ B, the bearing of line 11 is taken, and then of line 12; and so we proceed until the end of line 14; from whence, if visible, after taking the bearing

of line 15, we take the bearing of △ C, to which station we next remove the instrument, and verify the bearing of B C. We then take the bearing of C A, and after that of line 16, and proceed to close our work with line 20, the bearing of which should prove the same as at first taken from line 2.

The instrument is now taken to line 21. The nonius is adjusted to the bearing of line 7, to the most distant end of which the telescope is directed, and from it is taken the bearing of line 21; and the work proceeds in the same manner until the end of 26, where the instrument being set up, and directed from the bearing of line 26 to line 14, the bearing of this latter line should prove the same, or very nearly, as when taken in the first series; and this again proves the work.

It will not be possible at all times to set the theodolite over the trigonometrical station; but it is generally practicable to place it in line between two stations, so that the bearing thereof may be taken, from which a bearing may be taken to some spot on the first line from whence the bearing of the first line may be taken.

No directions that can be written will render a person an expert surveyor: practice alone will effect that. Enough has been said to convey a knowledge of the theory, the practice should be acquired under the instructions of some able master.

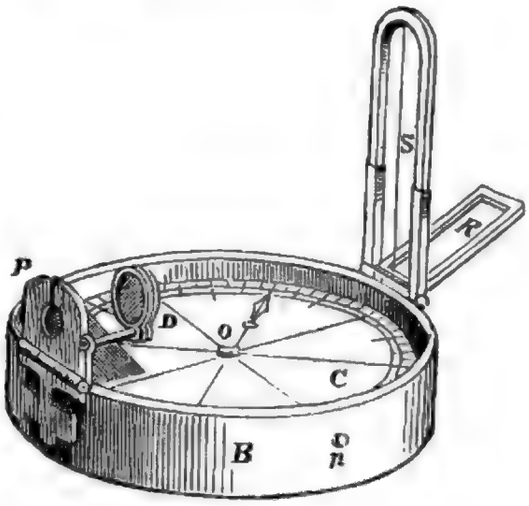
Sect. IV.—*Field Instruments.*

THE PRISMATIC COMPASS.

With this instrument horizontal angles can be observed with great rapidity, and, when used with a tripod stand, with a considerable degree of accuracy. It is, consequently, a very valuable instrument to the military surveyor, who can make his observations with it, while holding it in his hand, with all the accuracy necessary for a military sketch. It is also a useful instrument for filling in the detail of an extensive survey,* after the principal points have been laid down by means of observations made with

* The prismatic compass was used for this purpose by the gentlemen engaged in making the Ordnance Surveys.

the theodolite, hereafter to be described, and for any purpose in short, in which the portability of the instrument and rapidity of execution are of more importance than extreme accuracy.



C is a compass card divided usually to every 20′, or third part of a degree, and having attached to its under side a magnetic needle, which turns upon an agate centre, o, fixed in the box B; *n* is a spring which, being touched by the finger, acts upon the card, and checks its vibrations, so as to bring it sooner to rest when making an observation; S is the sight-vane, having a fine thread stretched along its opening, by which the point to be observed with the instrument is to be bisected. The sight-vane is mounted upon a hinge-joint, so that it can be turned down flat in the box when not in use. P is the prism attached to a plate sliding in a socket, and thus admitting of being raised or lowered at pleasure, and also supplied with a hinge-joint, so that it can be turned down into the box when not in use. In the plate to which the prism is attached, and which projects beyond the prism, is a narrow slit, forming the sight through which the vision is directed when making an observation. On looking through this slit, and raising or lowering the prism in its socket, distinct vision of the divisions on the compass card immediately under the sight-vane is soon obtained, and these divisions, seen through the prism, all appear, as each is successively brought into coincidence with the thread of the sight-vane by turning the instrument round, as continuations of the thread, which is seen directly through the part of the slit that projects beyond the prism.

The method of using the instrument is as follows:—The sight-vane S, and the prism P, being turned up upon their hinge-joints, as represented in our figure, hold the instrument as nearly in an horizontal position as you can judge; or, if it be used with a tripod stand, set it as nearly as you can in a horizontal position by moving the legs of the stand, so that the card may play freely. Raise the prism in its socket till the divisions upon the card are seen distinctly through the prism, and, turning the instrument round, until the object to be observed is seen through the portion

of the slit projecting beyond the prism in exact coincidence with the thread of the sight-vane, bring the card to rest by touching the spring *n*; and then the reading at the division upon the card, which appears in coincidence with the prolongation of the thread, gives the magnetic azimuth of the object observed, or the angle which a straight line, drawn from the eye to the object, makes with the magnetic meridian.* The magnetic azimuth of a second object being obtained in the same manner, the difference between these two azimuths is the angle subtended by the objects at the place of the eye, and, which is an important point, is independent of any error in the azimuths, arising from the slit in the prism not being diametrically opposite to the thread of the sight-vane.

For the purpose of taking the bearings of objects much above or below the level of the observer, a mirror, R, is supplied with the instrument, which slides on and off the sight-vane S, with sufficient friction to remain at any part of the vane that may be desired. It can be put on with its face either upwards or downwards, so as to reflect the images of objects considerably either above or below the horizontal plane to the eye of the observer; and, if the instrument be used for obtaining the magnetic azimuth of the sun, it must be supplied with dark glasses, D, to be interposed between the sun's image and the eye.

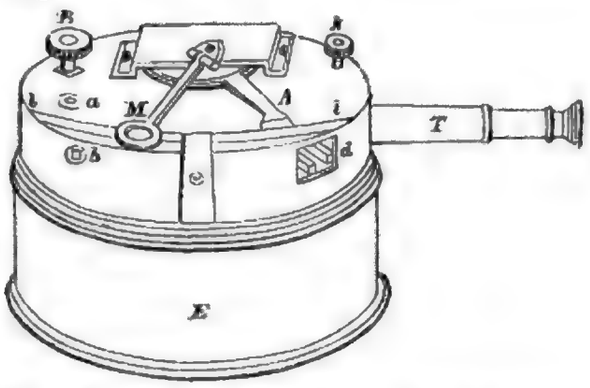
There is a stop in the side of the box, not shewn in our figure, by touching which a little lever is raised, and the card thrown off its centre, as it always should be when not in use, or the constant playing of the needle would wear the fine agate point upon which it is balanced, and the sensibility of the instrument would be thereby impaired. The sight-vane and prism being turned down, a cover fits on to the box, which is about three inches in diameter, and one inch deep; and the whole, being packed in a leather case, may be carried in the pocket without inconvenience.†

* The magnetic meridian now makes an angle of 24° with the true meridian at London, the north point of the compass being 24° west of the true north point. This angle is called the variation of the compass, and is different at different places, and also at the same place at different times. Since this variation will affect equally, or nearly so, all azimuths observed within a limited extent and during a limited time, the angles subtended by any two of the objects observed, being the difference of their azimuths, will not be affected by the variation, and hence the map, or plan, may be constructed with all the objects in their proper relative positions; but the true meridian must be laid down, if required, by observations made for the purpose.

† For much valuable information respecting the use of the prismatic compass, especially in military surveying and sketching, I can refer our readers to a Treatise on Military Surveying, &c., by Lieutenant-Colonel Basil Jackson, in which the subject is handled with great ability.

THE BOX SEXTANT.

This instrument, which is equally portable with the prismatic compass, forming, when shut up, a box of about three inches in diameter, and an inch and a half deep, will measure the actual angle between any two objects to a single minute. It requires no support but the hand, is easily adjusted, and, when once adjusted, but seldom requires re-adjusting.



When the sextant is to be used, the lid, E, of the box is taken off and screwed on to the bottom, where it makes a convenient handle for holding the instrument. The telescope, T, being then drawn out, the instrument appears as represented in our figure. A is an index arm, having at its extremity a vernier, of which thirty divisions coincide with twenty-nine of the divisions upon the graduated limb, *l l;* and the divided spaces upon the limb denoting each thirty minutes, or half a degree, the angles observed are read off by means of the vernier to a single minute. The index is moved by turning the milled head, B, which acts upon a rack and pinion within the box. To the index arm is attached a mirror, called the index glass, which moves with the index arm, and is firmly fixed upon it by the maker, so as to have its plane accurately perpendicular to the plane in which the motion of the index arm takes place, and which is called the plane of the instrument. This plane is evidently the same as the plane of the face of the instrument, or of the graduated limb, *l l.* In the line of sight of the telescope is placed a second glass, called the horizon glass, having only half its surface silvered, and which must be so adjusted that its plane may be perpendicular to the plane of the instrument, and parallel to the plane of the index glass when the index is at zero. The instrument is provided with two dark glasses, which can be raised or lowered by means of the little levers seen at *d*, so as to be interposed, when necessary, between the mirrors and any object too bright to be otherwise conveniently observed, as the sun. The eye-end of the telescope is also furnished with a dark glass, to be used when necessary.

The principle upon which the sextant is constructed is, that the total deviation of a ray of light, after reflections successively at the index glass and horizon glass, is double the inclination of the two glasses. Now the limb, *l l*, being di-

vided into spaces, each of 15′ extent, and these spaces being figured as 30′ each, the reading of the limb gives double the angle moved over by the index arm from the position in which the reading is zero, or double the angle of inclination of the two mirrors, if these mirrors be parallel when the reading is zero. If, then, the instrument be in perfect adjustment, and any object be viewed by it after reflection at both the mirrors, the reading of the instrument gives the total deviation of the rays of light, by which the vision is produced, or the angle between the bearing of the object from the centre of the index mirror, and the bearing of the reflected image from the place of the eye, that is, between lines drawn respectively from the object to the centre of the index glass, and from the reflected image in the horizon glass to the eye. This angle is very nearly equal to the angle subtended by the object and its image at the place of the eye, differing from it only by the small angle subtended at the object by the place of the eye and the centre of the index glass. This small angle is called the parallax of the instrument, and is scarcely perceptible at the distance of a quarter of a mile, while for distances greater than that it is so small that it may be considered to vanish. It also varies with the amount of deviation, and vanishes altogether whenever the centre of the index glass is in a direct line between the object and the eye.*

To see if the instrument be in perfect adjustment, place the dark glass before the eye-end of the telescope, and looking at the sun, and moving the index backwards and forwards a little distance on either side of zero, the sun's reflected image will be seen to pass over the disc, as seen directly through the horizon glass; and if, in its passage, the reflected image completely covers the direct image, so that but one perfect orb is seen, the horizon glass is perpendicular to the plane of the instrument; but, if not, the screw at *a* must be turned by the key, *k*, till such is the case. The key, *k*, fits the square heads of both the screws seen at *a* and *b*, and fits into a spare part of the face of the instrument, so as to be at hand when wanted. This adjustment being perfected, bring the reflected image of the sun's lower limb in exact contact with

* We have seen a method given for what is called correcting the parallax, when an observation is made at a short distance, by finding the deviation at this distance, when the angle between the object and its image is equal to zero; this deviation being given by the reading of the instrument, when the reflected image of the object observed exactly coincides with the object itself, seen through the unsilvered part of the horizon glass. This deviation, however, is not the parallax, even for a small angle between the object and its image, and, if the angle be not very small, the error introduced by the method will be greater than the parallax itself.

the direct image of his upper limb, and note the reading of the vernier; then move the index back, beyond the zero division of the limb, till the reflected image of the sun's upper limb is in exact contact with the direct image of his lower limb; and, if the zero of the vernier be now exactly as far behind the zero of the limb as it was at the former reading in front of it, so that the reading now on the part of the limb called the arc of excess, behind its zero division,* be the same as the former reading, the instrument is in perfect adjustment; but, if not, half the difference of the two readings is the amount of the error, and is called the index error, being a constant error, for all angles observed by the instrument, of excess, if the first reading be the greatest, and of defect, if the second reading on the arc of excess be the greatest.

In the former case, then, the true angle will be found by subtracting the index error from, and in the latter by adding it to, the reading of the instrument at every observation; but this error should be removed by applying the key, *k*, to the screw at *b*, and turning it gently till both readings are alike, each being made equal to half the sum of the two readings first obtained. When this adjustment is perfected, if the zeros of the vernier and limb are made exactly to coincide, the reflected and direct image of the sun will exactly coincide, so as to form but one perfect orb; and the reflected and direct image of any line, sufficiently distant not to be affected by parallax, as the distant horizon, or the top or end of a wall more than half a mile off, will coincide so as to form one unbroken line.

To obtain the angle subtended by two objects situated nearly or quite in the same vertical plane, hold the instrument in the right hand, and bring down the reflected image of the upper object by turning the milled head B, till it exactly coincides with the direct image of the lower object, and the reading of the instrument will give the angle between the two objects.

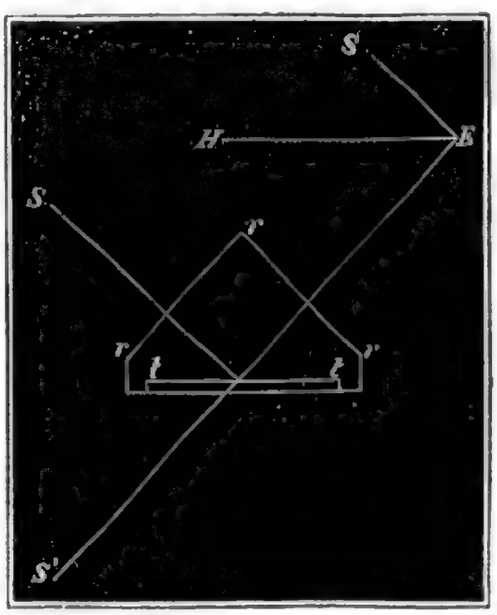
To obtain the angle subtended by two objects nearly in the same horizontal plane, hold the sextant in the left hand, and bring the reflected image of the right-hand object into coincidence with the direct image of the left-hand object.

* In reading an angle upon the arc of excess, the division to read on the limb is that next in front of the zero of the vernier, or between the zero of the vernier and the zero of the limb, and the divisions of the vernier itself are to be read from the end division, marked 30, and not, as usually, from the zero division: thus, if the zero division of the vernier were a little further from the zero division of the limb, then the first division on the arc of excess; and if the twenty-seventh division on the vernier, or the third from the end division, marked thirty, coincided with a division upon the limb, then the reading would be 33′.

It will be seldom that the surveyor need pay any attention to the small error arising from parallax; but, should great accuracy be desirable, and one of the objects be distant while the other is near, the parallax will be eliminated by observing the distant object by reflection, and the near one by direct vision, holding the instrument for this purpose with its face downwards if the distant object be on the left hand. If both objects be near, the reflected image of a distant object, in a direct line with one of the objects, must be brought into coincidence with the direct image of the other object, and the parallax will thus be eliminated.

For the purposes of surveying, the horizontal angles between different objects are required, and the reduction of these angles from the actual oblique angles subtended by the objects, would be a troublesome and laborious process. If the angle subtended by two objects be large, and one be not much higher than the other the actual angle observed will be, however, a sufficient approximation to the horizontal angle required; and, if the angle between the two objects be small, the horizontal angle will be obtained with sufficient accuracy by taking the difference of the angles observed between each of the objects, and a third object at a considerable angular distance from them. With a little practice, the eye will be able to select an object in the same direction as one of the objects, and nearly on a level with the other object, and the angle between this object and the object selected will be the horizontal angle required.

At sea the altitude of an object may be determined by observing the angle subtended by it and the verge of the horizon; but upon land a contrivance, called an *artificial horizon*, becomes necessary for correctly determining altitudes. The best kind of artificial horizon consists of an oblong trough, *t t*, filled with mercury, and protected from the wind by a roof, *r r*, having in either slope a plate of glass with its two surfaces ground into perfectly parallel planes. The angle S E S′ between the object and its reflected image seen in the mercury is double the angle of elevation S E H, and the angle S E S′ being observed, its half will consequently be the angle of elevation required. If the angle of ele-



vation be greater than 60°, the angle S E S′ will be greater than 120°, and cannot be observed with the sextant we have been describing.

The pocket sextant is a most convenient instrument for laying off offsets or perpendicular distances from a station line; for by setting the index at 90°, and walking along the station line, looking through the horizon glass directly at the further station staff, or any other remarkable object upon the station line, any object off the station line will be seen by reflection when the observer arrives at the point where the perpendicular from this object upon the station line falls, and the distance from this point to the object being measured, is its perpendicular distance from the station line.

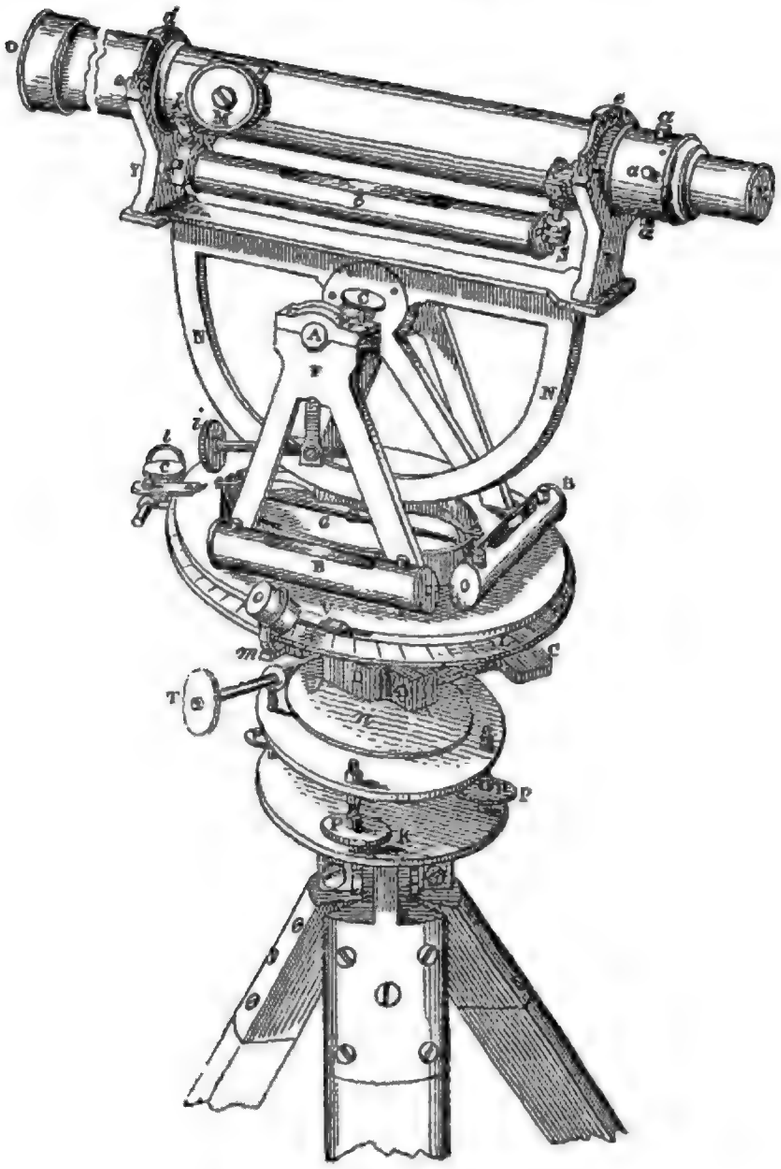
For the mere purpose of measuring offsets, an instrument called an *optical square* is now very generally employed, which consists of the two glasses of the sextant fixed permanently at an angle of 45°, so that any two objects seen in it, the one by direct vision, and the other by reflection, subtend at the place of the observer an angle of 90.

THE THEODOLITE.

The theodolite is the most important instrument used by surveyors, and measures at the same time both the horizontal angles subtended by each two of the points observed with it, and the angles of elevation of these points from the point of observation.

This instrument may be considered as consisting of three parts; the parallel plates with adjusting screws fitting on to the staff head; the horizontal limb, for measuring the horizontal angles; and the vertical limb, for measuring the vertical angles, or angles of elevation.

The horizontal limb is composed of two circular plates, L and V, which fit accurately one upon the other. The lower plate projects beyond the other, and its projecting edge is sloped off, or chamfered, as it is called, and graduated at every half degree. The upper plate is called the vernier plate, and has portions of its edge chamfered off, so as to form with the chamfered edge of the lower plate continued portions of the same conical surface. These chamfered portions of the upper plate are graduated to form the verniers, by which the limb is subdivided to single minutes. The five-inch theodolite represented in our figure has two such verniers, 180° apart. The lower plate of the horizontal limb is attached to a conical axis passing through the upper parallel plate, and terminating in a ball fitting in a socket upon the lower parallel plate.



A Five-inch Theodolite.

This axis is, however, hollowed to receive a similar conical axis ground accurately to fit it, so that the axes of the two cones may be exactly coincident, or parallel.* To the internal axis the upper, or vernier, plate of the horizontal limb is attached; and thus, while the whole limb can be moved through any horizontal angle desired, the upper plate only can also be moved through any desired angle, when the lower plate is fixed by means of the clamping screw, C, which tightens the collar, D: T is a slow-motion screw, which moves the whole limb through a small space, to adjust it more perfectly, after tightening the collar, D, by the clamping screw, C. There is also a clamping screw, *c*, for fixing the upper, or vernier, plate

* Upon this depends, in a great measure, the perfection of the instrument, as far as the horizontal measurements are concerned; and when we describe presently the adjustments of the instrument, we shall explain the method of detecting an inaccuracy in the grinding of the axes.

to the lower plate, and a tangent screw, *t*, for giving the vernier plate a slow motion upon the lower plate, when so clamped. Two spirit levels, B B, are placed upon the horizontal limb, at right angles to each other, and a compass, G, is also placed upon it in the centre, between the supports, F F, for the vertical limb.

The vertical limb, N N is divided upon one side at every 30 minutes, each way, from 0° to 90°, and subdivided by the vernier, which is fixed to the compass box, to single minutes. Upon the other side are marked the number of links to be deducted from each chain, for various angles of inclination, in order to reduce the distances, as measured along ground rising or falling at these angles, to the corresponding horizontal distances. The axis, A, of this limb must rest in a position truly parallel to the horizontal limb, upon the supports, F F, so as to be horizontal when the horizontal limb is set truly level, and the plane of the limb, N N, should be accurately perpendicular to its axis. To the top of the vertical limb, N N, is attached a bar which carries two Ys for supporting the telescope, which is of the same construction as the Y spirit level, and underneath the telescope is a spirit level, S S, attached to it at one end by a joint, and at the other end by a capstan-headed screw as in the Y level. The horizontal axis, A, can be fixed by a clamping screw, C, and the vertical limb can then be moved through a small space by a slow-motion screw *i*.

Before commencing observations with this instrument, the following adjustments must be attended to:—

1. Adjustments of the telescope: viz.,
 the adjustment for parallax.
 ——————— for collimation.
2. Adjustment of the horizontal limb: viz.,
 to set the levels on the horizontal limb to indicate the verticality of the azimuthal axis.
3. Adjustment of the vertical limb: viz.,
 to set the level beneath the telescope to indicate the horizontality of the line of collimation.

1. *Parallax and Collimation.*—These adjustments are described under the head of the Y level.

2. *Adjustment of the Horizontal Limb.*—Set the instrument up as accurately as you can by the eye, by moving the legs of the stand. Tighten the collar, D, by the clamping screw, C, and unclamping the vernier plate, turn it round till the telescope is over two of the parallel plate-screws. Bring the bubble, *b*, of the level, S S, beneath the telescope to the centre of its run by turning the tangent

screw, *i*. Turn the vernier plate half round, bringing the telescope again over the same pair of the parallel plate screws; and if the bubble of the level be not still in the centre of its run, bring it back to the centre half way, by turning the parallel plate screws over which it is placed, and half way by turning the tangent screw, *i*. Repeat this operation till the bubble remains accurately in the centre of its run in both positions of the telescope; and then turning the vernier plate round till the telescope is over the other pair of parallel plate screws, bring the bubble again to the centre of its run by turning these screws. The bubble will now retain its position, while the vernier plate is turned completely round, shewing that the internal azimuthal axis about which it turns is truly vertical. The bubbles of the levels on the vernier plate being now, therefore, brought to the centres of their tubes, will be adjusted to shew the verticality of the internal azimuthal axis. Now, having clamped the vernier plate, loosen the collar, D, by turning back the screw, C, and move the whole instrument slowly round upon the external azimuthal axis; and if the bubble of the level, S S, beneath the telescope, maintains its position during a complete revolution, the external azimuthal axis is truly parallel with the internal, and both are vertical at the same time; but, if the bubble does not maintain its position, it shews that the two parts of the axis have been inaccurately ground, and the fault can only be remedied by the instrument-maker.

3. *Adjustment of the Vertical Limb.*—The bubble of the level, S S, being in the centre of its run, reverse the telescope end for end in the Ys, and if the bubble does not remain in the same position, correct for one-half the error by the capstan-headed adjusting screw at one end of the level, and for the other half by the vertical tangent screw, *i*. Repeat the operation till the result is perfectly satisfactory. Next turn the telescope round a little both to the right and to the left, and if the bubble does not still remain in the centre of its run, the level, S S, must be adjusted laterally by means of the screw at its other end. This adjustment will probably disturb the first, and the whole operation must then be carefully repeated. By means of the small screw fastening the vernier of the vertical limb to the vernier plate over the compass box, the zero of this vernier may now be set to the zero of the limb, and the vertical limb will be in perfect adjustment.

With an increase in the size of the theodolite, a second telescope is placed beneath the horizontal limb, which serves to detect any accidental derangement of the instrument during an observation, by noting whether it is directed to the same point of a distant ob-

ject at the end of the observation to which it has been set at the commencement of the observation. Also the vertical limb, in the larger theodolites, admits of an adjustment to make it move accurately in a vertical plane, when the horizontal limb has been first set in perfect adjustment. This adjustment is important, and should be examined with great care; and in the small theodolites, when the vertical limb is permanently fixed to the horizontal limb by the maker, an instrument which will not bear the test of the examination which we proceed to describe must be condemned, till set in better adjustment by the maker. The azimuthal axis having been set truly vertical, direct the telescope to some well-defined angle of a building, and making the intersection of the wires exactly coincide with this angle near the ground, elevate the telescope by giving motion to the vertical limb; and if the adjustment be perfect, the intersection of the cross wires will move accurately along the angle of the building, still continuing in coincidence with it. A still more perfect test will be to make the intersection of the cross wires coincide with the reflected image of a star in an artificial horizon, and elevating the telescope, if the adjustment be perfect, the direct image of the star itself will again be bisected by the cross wires.

THE USE OF THE THEODOLITE.

To take an angle, whether between the magnetic meridian and a given line or object, whether between any two given lines, or at one given point between any other given points.

Open the tripod stand, so that the centre is as nearly as possible over the centre of the station, which can be ascertained by a plummet, [or what is better (inasmuch as it is always attainable when wanted, and no encumbrance when done with, because it can be thrown away), a stone tied to a string.] Level the instrument by means of the parallel plate-screws, and the levels B B; then if the angle required is one with the magnetic meridian, set the needle in motion, unclamp the upper and lower plates of the limb, and bring the zero division on the vernier to zero on the lower plate. Clamp the plates approximately by the clamp screw, and accurately adjust them by the slow-motion screw. Unclamp the screw C, and bring the letter N, in the compass-box, to the marked end of the needle, by turning the whole body of the instrument. Clamp it approximately by the screw C, and exactly adjust it by the slow-motion screw D. The telescope and zero division of the scale is now in the magnetic meridian. Unclamp the upper and lower plates, and direct the telescope at the given object. Reclamp the limb approximately with the clamp screw, and exactly bring the

cross hairs of the telescope to intersect the object by means of the slow-motion screw. The angle then indicated by the instrument, is the measure of the angle required. If the measure of an angle between two lines or between two objects is required, the process is similar; excepting only, that part of it that relates to the magnetic needle, which is in this case not required; it is simply necessary to place zero on the graduated arc with zero on the vernier, and direct the telescope at the left-hand object instead of in the magnetic meridian, as in the former case.

Most theodolites are furnished with two verniers on the upper plate: one corresponding with zero on the lower limb, and the opposite one with the mark denoting 180°. In taking the bearings of lines these verniers are very useful, as giving the true and apposite bearing, but in the simple process of measuring angles, one only is requisite.

To read an angle taken by the theodolite, it is necessary to understand the vernier scale—a very beautiful and ingenious contrivance, by means of which the half degrees on the lower plate are accurately divided into single minutes.

The 30 minutes represented by the vernier, are equal in length to 29 degrees on the graduated arc. Now, it is evident by the fig. 171, the divisions on the vernier being 30, while those on the graduated arc are 29, every division of the vernier must be one-thirtieth of a division on the graduated arc, less than such division; and, consequently, if the vernier is moved along until division 1 upon it is in contact with the first division or half degree on the graduated arc, the zero of the vernier has moved one-thirtieth part of such half degree or one minute; if 5 on the vernier is brought in contact with the fifth division, or $2\frac{1}{2}$ degrees on the graduated arc, then zero of the vernier must have moved five-thirtieths or five minutes, so that by this contrivance the most minute subdivision is accomplished.*

A vertical angle, or an angle of elevation or depression, is taken with the theodolite by means of the vertical limb. Having levelled the body of the instrument as before described, bring the bubble of the telescope level into the centre of its run by means of the clamp screw *c*, and slow-motion screw *i*; observe that zero on the vernier and zero on the vertical arc are together, and then unclamp the vertical limb; raise or depress the telescope until the cross hairs intersect the object, and the angle denoted by the vernier on the

* A description of the vernier in this place will explain its use in every case to which it can be applied. It often assumes various forms, but is so simple, that it must be apparent to every mathematical mind.

vertical arc, will be the angle of elevation or depression, as the case may be, which was required.

If the telescope be reversed in the Ys, and the angle taken with the other end, the mean of the two readings, if they differ, will be the nearest approach to accuracy, inasmuch as an error in the adjustment of the vernier is thereby counteracted.

CHAPTER VIII.

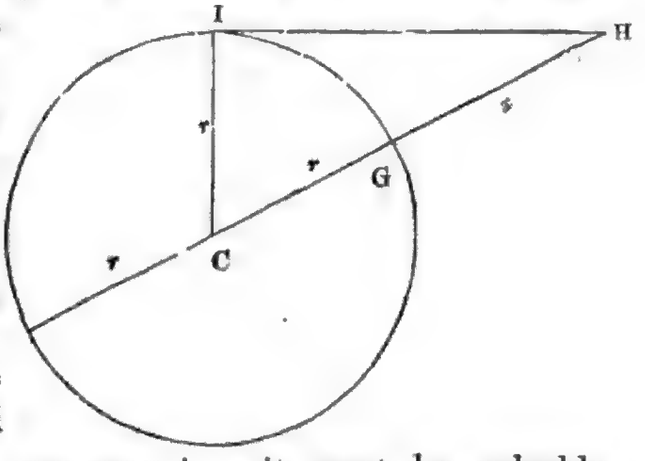
LEVELLING

Is the art of tracing a line equidistant from the earth's centre,* which shall cut the directions of gravity everywhere at right angles.

The earth being a globe, it is evident that the operation of levelling does not consist in simply ascertaining the undulations of the earth above or below any given horizontal line which may be assumed to form its surface, as an extended plane, but in determining the relative distances of different places from the earth's centre.

In other words, a level line is not, as is frequently supposed, a true horizontal line, but the arc of a circle; so that if it were possible to start from London, and level round the world, the accurate level line would meet at precisely the same spot as that from which it started.

It is therefore obvious that any instrument calculated to take horizontal levels only, must, beyond a certain distance, become appreciably in error, and require correction for curvature. The horizontal line I H, in the figure, is the line which would be made by a levelling instrument standing at the point I, and for a certain distance (the relative diameter of the circle being considered), there would be no appreciable difference between the apparent and true level; but to shew my meaning, it must be palpably obvious that the point H is considerably farther from the centre



* Supposing the earth a perfect sphere, which is not quite the case, but sufficiently near for our purpose, the length of the equatorial diameter being 7,924 miles, while the polar is only 7,898, the difference is only 26 miles or $\frac{1}{305}$ part.

C than the point G is, and therefore it is not in the true level; and if any level is taken at a greater distance than ten chains, this error of curvature must be allowed for.

In addition to this error, on account of curvature, is another, occasioned by refraction. It is well known that an object is never seen by us in its true position, but in the direction of the ray of light, which conveys the impression or image of the object to our senses, the most curious of all, and as yet (at all events to me) unexplained arrangement being, that the vertical position in which every reflected image is left in the eye of the observer when intercepted by the colouring matter that lines the back of the eye, is the reverse of reality, notwithstanding the correction of this anomaly, which takes place in the transference of the reflected image to the mind.

The particles of light, in traversing the atmosphere, are always bent towards the perpendicular, and consequently describe a curved track, which to a certain extent modifies the effect of curvature in levelling, and renders it only necessary, in correcting for curvature, to do so to the extent to which the error is diminished by refraction.

Table 20, chap. I, shews the difference between the apparent and true level, both in respect of curvature and refraction.

The practice of levelling requires greater care than any other operation in surveying, owing to the numerous chances of error, and the great difficulty of detecting it, without going over the whole operation again; notwithstanding which, when skilfully and circumspectly performed, the accuracy of the results may be demonstrated to a degree, exceeding if possible the proofs of a trigonometrical survey. For instance, suppose a series of levels to be taken along the principal roads of a country, and afterwards by circuitous routes, and a variety of methods, the levels of the branch roads are taken, commencing at a given point on the main line, and crossing it again and again, and finally terminating upon some other point of the main line: if at these crossings, and at the termination of the branch levelling, the reduced levels come out within a few hundredth parts of a foot of the reduced levels of the main line, there is little doubt that the levelling is correct.

The most satisfactory piece of levelling, within my practice, occurred in the autumn of 1849. I was employed by the promoters of a public company to take about thirty-five miles of parliamentary levels,* commencing with a "Datum line one hundred feet

* Levels from which a section is to be made for deposit in Parliament, on the 30th of November, in compliance with the Standing Orders of the House.

below the stone sill of the south door to Wandsworth Old Church, in the High Street, close to the middle of the door-post, on the east side of the door." I subsequently discovered that the promoters had, as a wise precaution against error, also employed another gentleman to take the same levels.

When the levels were completed, myself and colleague met to compare notes.

The following are a few of the results :—

		MY OWN.	THOSE OF MY FRIEND.	DIF.
B. M.*	At Wandsworth Church .	100	100	
	Fork of Roads near the Printing Works . .	111·76	111·67	·09
	Branch Roads near the Plough Inn	111·65	111·63	·02
B. M.	Mitcham Church . . .	148·05	147·94	·11
	A Junction near Mitcham Common	159·33	159·30	·03
B. M.	On a Direction Post near Hackbridge	167·00	166·94	·06
B. M.	On the front of large House.	173·75	173·65	·10
	Junction of Roads . .	164·95	164·94	·01
	At Angle of Roads . .	130·11	129·98	·13
	Centre of Bridge near the Snuff Mills . . .	141·58	141·47	·11
	Junction of Branch . .	192·17	192·13	·04
	Level of Water at Ford .	191·28	191·27	·01
	At Waddon	215·38	215·27	·11
	The near side down Rail of Epsom Railway. . .	224·62	224·56	·06
B. M.	On Croydon Church, being the close of work, on the stone sill of the principal door under the tower	228·11	228·10	·01

It will be seen that the greatest variation is ·13, and that being only at an undefined point on a road, it is quite possible that a difference of a few hundredths might be made in holding the staff.

* B. M. is the short way of writing Bench Mark, which signifies a firm permanent feature that can at any time be referred to. A mark on a brick or stone wall makes a good Bench Mark; they are generally cut in the form represented in fig. 172. The horizontal line A B being the level referred to.

The curious in such matters will observe, that my results are in every instance the greater, and but that the levels of the Bench Marks also vary on the same way, I should account for it by the fact, that while my staff-holders used a tripod, those of my colleague did not. The above is inserted to shew the great accuracy with which levelling operations can be carried on.

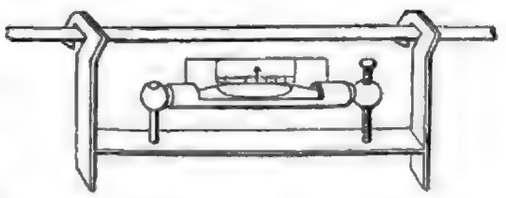
It is usual in levelling to compute all the heights from one common datum (imaginary) line, so that the relative level of any two places may be readily ascertained by the simple subtraction of one height from another. For instance, a place thirty feet above datum is ten feet higher than another that is twenty feet above datum. It is desirable that this datum line should be chosen below the lowest point to be levelled, so that all the heights may be positive quantities, which could not be the case were some above and others below datum. It does not of course follow, nor is it desirable that a datum line should coincide with any one known point, it is sufficient that it refers to it; hence it is customary to assume the datum to be 100 (or any other even number) below some known permanent point, which can always be referred to.

Levelling Instruments.

THE SPIRIT LEVEL.

The spirit level consists of a glass tube, differing from the cylindrical form by having its diameter largest in the middle, and decreasing slightly and with great regularity from the middle to the ends. The tube is nearly but not quite filled with spirits of wine, thus leaving in it a bubble of air, *b b*, which rises to the highest part of the tube, so as to have its two ends equally distant from the middle, when the instrument is in adjustment, as represented in the annexed figure. The tube is generally fitted into another tube of metal, and attached to a frame terminating in angular bearings, by which the level can either be suspended from, or else be stood upon, cylindrical pivots. When, however, the level forms a permanent part of any instrument, the manner of attaching it is modified to suit the particular form of the instrument to which it is attached. A small and accurately-divided scale is attached to the best instruments, or otherwise a scale is scratched upon the glass tube itself, as represented in the figure given ante.





The annexed figure is a representation of such a level as is used for levelling the axis of the best astronomical instruments. It is provided with a fixed scale, seen in the figure, and is suspended by means of accurately constructed angular bearings.

The following criteria of a good level are extracted from Dr. Pearson's valuable work on Practical Astronomy.

"Firstly, the bubble must be long enough, compared with the whole tube, to admit of quick displacement, and yet not too long to admit of its proper elongation by low temperature.

"Secondly, the curve must be such, that the sensibility and uniform run of the bubble will indicate quantities sufficiently minute, while those quantities correspond exactly to the changes of inclination, as read on the graduated limb of the instrument of which it forms a part.

"Thirdly, the bubble must keep its station when the angles are moved a little round the pivots of suspension.

"Fourthly, the opposite ends of the bubble must vary alike in all changes of temperature, or, in other words, the ends of the bubble must elongate or contract alike in opposite directions, so that the middle point may always be stationary.

"Fifthly, the angles of the metallic end-pieces must be so nicely adjusted that reversion on horizontal pivots that are equal will not alter the place of the bubble.

"Sixthly, the distance between the two zeros of a fixed scale, when such a graduated scale is used, should be equal to the length of the bubble at the temperature of 60° of Fahrenheit's scale, and should be marked at equal distances from the visible ends of the glass tube. Then, as the bubble lengthens by cold, or shortens by heat, its extreme ends may always be referred to these fixed marks, 0 0, on the scale, and will fall either within, upon, or beyond them, according to the existing temperature. The number of sub-divisions of the scale that each end of the bubble is standing at, counted from the fixed zero marks, at the instant of finishing an observation, must always be noted, that an allowance may be made for the value of the deviation in seconds, or as the case may require.

"Seventhly, when the two ends of the bubble are not alike affected by a change of temperature, the scale should be detached, and adjustable to the new zero points, by an inversion of the level.

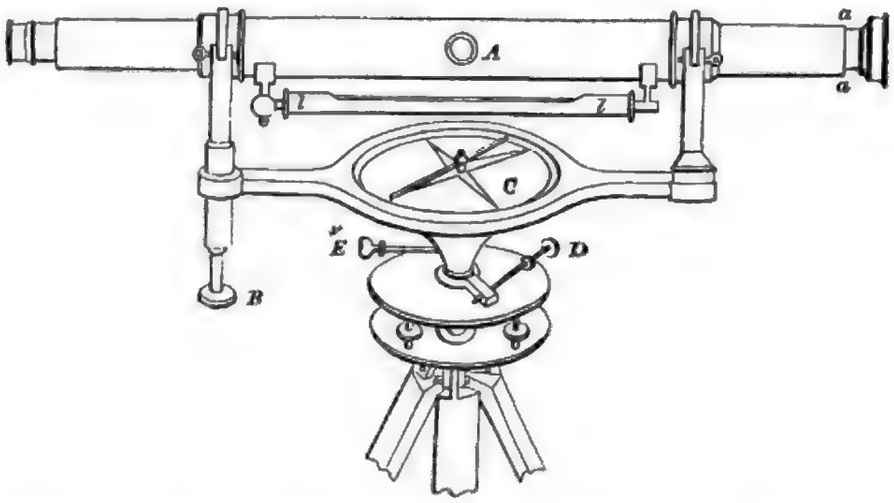
"Eighthly, when the scale has only one zero at its centre, which is a mode of dividing the least liable to misapprehension, the positions must be reversed at each observation, and both ends of the bubble read in each position; for in this case, if any change has taken place in the true position of this zero, the resulting error will merge in the reduction of the observation. This mode of graduating is generally practised on the continent."

I now proceed to the description of the most accurate instruments for measuring the differences of level, or vertical distances, between different stations.

Of spirit levels, for this purpose there are now three in use, namely, the Y level, Troughton's improved level, and Gravatt's level.

THE Y LEVEL.

The following figure represents this instrument. A is an achromatic telescope, resting upon two supporters, which in shape resemble the letter Y, and are consequently called the Ys. The lower ends of these supporters are let perpendicularly into a strong



bar, which carries a compass box, C. This compass box is convenient for taking bearings, and has a contrivance for throwing the needle off its centre, when not in use. One of the Y supporters is fitted into a socket, and can be raised or lowered by the screw B.

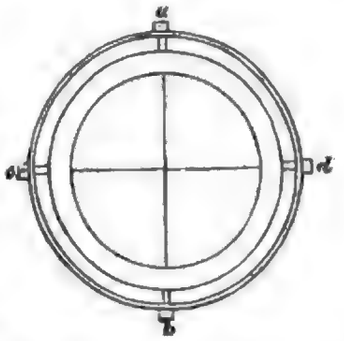
Beneath the compass box, which is generally in one piece with the bar, is a conical axis passing through the upper of two parallel plates, and terminating in a ball supported in a socket. Immediately above this upper parallel plate is a collar, which can be made to embrace the conical axis tightly by turning the clamping screw E, and a slow horizontal motion may then be given to the instrument by means of the tangent screw D. The two parallel plates are connected together by the ball and socket already mentioned, and are set firm by four milled-headed screws, which turn in sockets fixed to the lower plate, while their heads press against the under side of the upper plate, and thus serve the purpose of setting the instrument up truly level.

Beneath the lower parallel plate is a female screw, adapted to the staff-head, which is connected by brass joints with three mahogany legs, so constructed as, when shut together, to form one round staff, a very convenient form for portability, and, when opened out, to make a very firm stand, be the ground ever so uneven.

The spirit level *l l* is fixed to the telescope by a joint at one end, and a capstan-headed screw at the other, to raise or depress it for adjustment.

In looking through a telescope a considerable field of view is embraced; but the measurements indicated by any instrument, of which the telescope may form a part, will only have reference to one particular point in this field of view, which particular point is considered as the centre of this field of view. We must therefore place some fixed point in the field of view, and in the focus of the eye-piece, and the point to which the measurement will have reference will be that point of the object viewed, which appears to be coincident with this fixed point, or which, as the technical phrase is, is bisected by the fixed point.

The intersection of two fixed lines will furnish us with such a fixed point, and consequently two lines of spider's web are fixed at right angles to each other in the focus of the eye-piece. They are attached by a little gum to a brass ring of smaller dimensions than the tube of the telescope, and which is fixed to the tube by four small screws, *a*, *b*, *c*, *d*. If the screw *d* be eased, while at the same time *c* is tightened, the ring will be moved to the right; but if *c* be eased and *d* tightened, the ring will be moved to the left; and in a like manner it may be moved up or down by means of the screws *a* and *b*.



When the instrument is in adjustment, the axis of the tube of the telescope is set truly horizontal by means of the level beneath it, and the line of observation ought consequently to be parallel to this axis. Let A represent the proper position of the intersection of the cross wires, and O A the direction of the axis of a pencil of light passing through the object-glass and coming to its focus at A. Then, the axis of the tube of the telescope being set truly horizontal, the line A O is also truly horizontal, and every point bisected by the intersection of the cross wires will be situated on the prolongation of the horizontal line A O.



Suppose now the position of the diaphragm carrying the cross wires to have become deranged, so that the point of intersection is moved to B, then every point bisected by the intersection of the cross wires will be on the prolongation of the line B O, and will consequently be below the true level point on the line A O.

Let now the telescope be turned half round in the Ys, and let the annexed figure represent it in its new position; then, in this new position of the telescope, the prolongation of the line B O will rise above the prolongation of the level line A O, and at the same distance from the telescope, the point now bisected by the intersection of the cross wires will be as much above the true level point on the line A O as the point before bisected by them was below it. The true level point is therefore midway between the two points observed in the two positions of the telescope, and the diaphragm carrying the cross wires is to be moved by means of the screws *a*, *b*, *c*, *d*, till their point of intersection coincides with that true level point. The telescope is then to be again turned round upon the Ys, and if the same point be still bisected by the intersection of the cross wires, they are in their proper position; but if not, the same method of adjustment must be repeated till the same point is bisected by the intersection of the cross wires in every position of the telescope.



This error of derangement has a technical denomination. The line O A, or O B, from O to the point of intersection of the cross wires, is called the *line of collimation*, and the error arising from their derangement, the method of detecting and correcting which, I have shewn, is called the *error of collimation*.

When the image of the object viewed, formed by the object-glass, either falls short of, or beyond the place of, the cross wires, the error arising from this cause is called *parallax*. The existence of parallax is determined by moving the eye about when looking through the telescope, observing whether the cross wires change their position, and are flittering and undefined.

To correct this error, first adjust the eye-piece by means of the moveable eye-piece tube, till you can perceive the cross wire clearly defined, and sharply marked against any white object.

Then by moving the milled-headed screw A, at the side of the telescope, the internal tube *a* is thrust outwards or drawn inwards, until you obtain the proper focus, according to the distance of the object, and you are enabled at once to see clearly the object, and the intersection of the wires, clearly and sharply defined, before it. The existence of parallax is very inconvenient, and where disre-

garded, has frequently been productive of serious error. It will not always be found sufficient to set the eye-glass first, and the object-glass afterwards. The setting of the object-glass, by introducing more distant rays of light, will affect the focus of the eye-glass, and produce parallax or indistinctness of the wires, when there was none before; the eye-piece must, in this case, be adjusted again.

Generally, when once set for the day, there is no occasion for altering the *eye-glass*, but the *object-glass* will of course have to be altered at every change of distance of the object.

In adjusting the instrument, the parallax should be first corrected, and then the error of collimation. The line of collimation being thus brought to coincide with the axis of the tube of the telescope, two further adjustments are necessary: the first to adjust the bubble-tube, so that it may truly indicate when the axis of the telescope is horizontal; and the second to set the axis of the telescope perpendicular to the vertical axis round which the instrument turns.

To adjust the Bubble-Tube.—Move the telescope till it lies in the direction of two of the parallel plate screws, and by giving motion to these screws bring the air bubble to the centre of its run. Now reverse the telescope carefully in the Ys, that is, turn it end for end; and should the bubble not settle at the same point of the tube as before, it shews that the bubble-tube is out of adjustment, and requires correcting. The end to which the bubble retires must then be noticed, and the bubble made to return one-half the distance by turning the parallel plate screws, and the other half by turning the capstan-headed screw at the end of the bubble-tube. The telescope must now again be reversed, and the operation be repeated, until the bubble settles at the same point of the tube, in the centre of its run, in both positions of the instrument. The adjustment is then perfect, and the clips which serve to confine the telescope in the Ys should be made fast.

Lastly, to set the Axis of the Telescope perpendicular to the Vertical Axis round which the Instrument turns.—Place the telescope over two of the parallel plate screws, and move them, unscrewing one while screwing up the other, until the bubble of the level settles in the centre of its run; then turn the instrument half round upon the vertical axis, so that the contrary ends of the telescope may be over the same two screws, and if the bubble does not again settle at the same point as before, half the error must be corrected by turning the screw B, and the other half by turning the two parallel plate screws over which the telescope is placed. Next turn

the telescope a quarter round, that it may lie over the other two screws, and repeat the process to bring these two screws also into adjustment; and when, after a few trials, the bubble maintains exactly the same position in the centre of its run, while the telescope is turned all round upon the axis, this axis will be truly vertical, and the axis of the telescope being horizontal by reason of the previous adjustment of the bubble-tube, will be perpendicular to that vertical axis, and remain truly horizontal, while the telescope is turned completely round upon the staves. The adjustment is therefore perfect.

The object of the above adjustments is to make the line of collimation move round in a horizontal plane, when the instrument is turned round its vertical axis, and the methods above explained suppose that the telescope itself is constructed with the utmost perfection, so that the axis of the tube carrying the object-glass is always in the same straight line with the axis of the main tube, which carries the diaphragm with the cross wires. If this perfection in the construction of the instrument does not exist, the line of collimation will vary, as the tube carrying the object-glass is thrust out, and drawn in, to adjust the focus for objects of different distances. What is really required then is, that the cross wires be so adjusted that the line of collimation may be in the same straight line with the line in which the centre of the object-glass is moved, and that the bubble of the level be at the centre of its run, when this line of collimation is directed to view objects, at the same level, or at the same distance from the centre of the earth.

We are indebted to Mr. Gravatt, of whose level I shall hereafter speak, for a method of collimating, which satisfies the above requirements, and removes any error arising from imperfection in the slide of the telescope, while at the same time the line of collimation is set with the end at the object-glass, slightly depressed, instead of exactly horizontal, so as to remove, or nearly so, the errors arising from the curvature of the earth, and the horizontal refraction.

To examine and correct the Collimation by Mr. Gravatt's Method.—"On a tolerably level piece of ground drive in three stakes at intervals of about four or five chains, calling the first stake *a*, the second *b*, and the third *c*.

"Place the instrument half way between the stakes *a* and *b*, and read the staff A, placed on the stake *a*, and also the staff B, placed on the stake *b*; call the two readings A′ and B′; then, although the instrument be out of adjustment,* yet the

* The axis of the instrument is to be set vertical by means of the parallel plate screws, by placing the telescope over each pair alternately, and moving them until the air bubble remains in the same position, when the instrument is turned half round upon its axis.

points read off will be equidistant from the earth's centre, and consequently level.

"Now remove the instrument to a point half way between *b* and *c*. Again, read off the staff B, and read also a staff placed on the stake *c*, which call staff C (the one before called A being removed into that situation.) Now, by adding the difference of the readings on B (with its proper sign) to the reading on C, we get three points, say A′, B′, and C′, equidistant from the earth's centre, or in the same true level.

"Place the instrument at any short distance, say half a chain beyond it, and using the bubble merely to see that you do not disturb the instrument, read all three staffs, or, to speak more correctly, get a reading from each of the stakes, *a*, *b*, *c*; call these three readings A″, B″, C″. Now, if the stake *b* be half way between *a* and *c*,* then ought $C'' - C' - (A'' - A')$ to be equal to $2[B'' - B' - (A' - A')]$; but if not, alter the screws which adjust the diaphragm, and consequently the horizontal spider line or wire, until such be the case; and then the instrument will be adjusted for collimation.

"To adjust the spirit bubble without removing the instrument, read the staff A, say it reads A‴, then adding $(A''' - A')$ with its proper sign to B′ we get a value, say B‴.

"Adjust the instrument by means of the parallel plate screws †, to read B‴ on the staff B.

"Now, by the screws attached to the bubble-tube, bring the bubble into the centre of its run.

"The instrument will now be in complete practical adjustment for level, curvature, and horizontal refraction, for any distance not exceeding ten chains, the maximum error being only $\frac{1}{1000}$th of a foot."

Before making observations with this instrument, the adjustments should be carefully examined and rectified, after which the screw B should never be touched; but at each station the parallel plate screws alone should be used for setting the axis round which the instrument turns truly vertical, when, in consequence of the adjustments previously made, the line of collimation will be truly level. For this purpose the telescope must be placed over each pair of the parallel plate screws alternately, and they must be moved till the air bubble settles in the middle of the level, and the operation being repeated till the telescope can be turned quite round upon the staff-head, without any change taking place in the position of the bubble, the instrument will be ready to read off the graduations upon the levelling staves, which we proceed to describe.

In all work where great accuracy is required, the Y level above described, is preferable to either of the others; but both Trough-

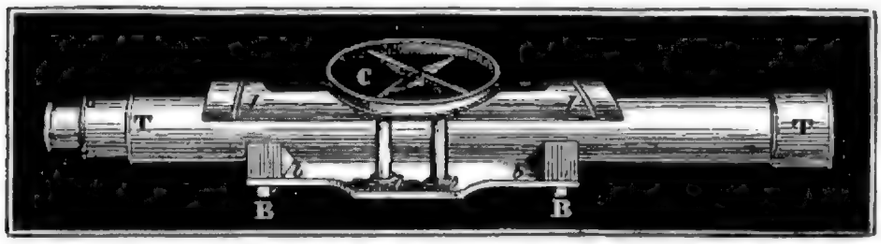
* Whatever be the distances between the stakes *a*, *b*, and *c*, the following proportions ought to hold, viz.:—

The distance from *a* : *b* : the distance *a* to *c* : : $B'' - B' - (A'' - A'.) : C'' - C' - (A'' - A'.)$

† If this adjustment be made by the screw B, instead of the parallel plate screws, the line of collimation will be brought into its proper position with respect to the vertical axis.

ton's level and Gravatt's level are calculated, by their lightness, and by their being less liable to derangement when once properly adjusted, to get rapidly over the ground.

TROUGHTON'S LEVEL.



In this level the telescope T, rests close down upon the horizontal bar, *b b*, the spirit level, *l l*, is permanently fixed to the top of the telescope, and does not, therefore, admit of adjustment, and the compass box, C, is supported over the level by four small pillars attached to the horizontal bar. This construction makes the instrument very firm and compact. The staves, staff-head, and parallel plates by which the instrument is supported, and the vertical axis upon which it turns, are of exactly the same construction as has been already described as used for supporting the Y level.

The diaphragm is furnished with three threads, two of them vertical, between which the levelling staff may be seen, and the third, horizontal, gives the reading of the staff by its coincidence with one of the graduations marked upon it. Sometimes a pearl micrometer scale is fixed on the diaphragm, instead of the wires. The central division on the scale, then, indicates the collimating point, and by its coincidence with a division of the levelling staff gives the required reading of this staff; and the scale serves the purpose of measuring distances approximately, and of determining stations nearly equidistant from the instrument, since at such equal distances the staff will subtend the same number of divisions upon the micrometer-scale.

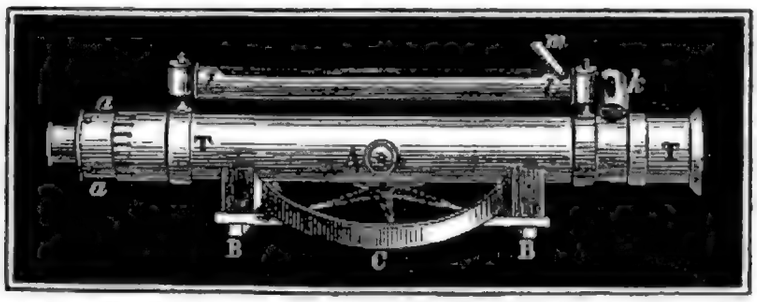
In selecting a level of Troughton's construction, and also in testing and adjusting the collimation subsequently, Mr. Gravatt's method, already described, is the best to be used; and when the line of collimation is thus brought into adjustment, if the bubble be far from the centre of its run, the fault can only be remedied by the maker; but if the bubble settle very nearly in the centre of its run, the instrument may be deemed a good one, and the divisions on the glass tube which coincide with the ends of the bubble being noted, the instrument must be set up for use with the bubble in this position.

The line of collimation is set perpendicular to the vertical axis

in the same manner as in the Y level, by means of the capstan screws B B, the bubble being made to maintain the requisite position, as above determined, while the instrument is turned completely round on its axis.

MR. GRAVATT'S LEVEL.

This instrument is furnished with an object-glass of large aperture and short focal length; and sufficient light being thus obtained



to admit of a higher magnifying power in the eye-piece, the advantages of a much larger instrument are obtained, without the inconvenience of its length. The diaphragm is carried by the internal tube *a a*, which is nearly equal in length to the external tube. The external tube T T is sprung at its aperture, and gives a steady and even motion to the internal tube *a a*, which is thrust out, and drawn in, to adjust the focus for objects at different distances by means of the milled-headed screw A. The spirit level is placed above the telescope, and attached to it by capstan-headed screws, one at either end, by means of which the bubble can be brought to the centre of its run, as in the case of the Y level, when the line of collimation is brought to the proper level by Mr. Gravatt's method of adjustment, already explained.

The telescope is attached to a horizontal bar, in a similar manner to Troughton's level, but room is just left between the telescope and the bar for the compass-box.

A cross level, *k*, is placed upon the telescope at right angles to the principal level *l l*, by which we are enabled to set the instrument up at once with the axis nearly vertical. A mirror, *m*, mounted upon a hinge-joint, is placed at the end of the level, *l l*, so that the observer, while reading the staff, can at the same time see that the instrument retains its proper position—a precaution sometimes desirable in windy weather, or on bad springy ground.

The telescope is attached to the horizontal bar by capstan-headed screws, B B, as in Troughton's level, by which the line of collimation is set perpendicular to the vertical axis; and the instrument is set up upon parallel plates, as before described, for the Y level.

The level I use, and which was specially constructed for me by the Messrs. Elliott is without either the cross level, the compass-box, or the mirror; the advantages obtained from the occasional use of which, not being equal in my estimation, to the benefits arising from the use of a light instrument, divested of every unnecessary encumbrance.

Levelling Staves.

One kind of staff has superiority over another only in the degree of its applicability to the purposes for which it is required—hence a folding staff is more handy for travelling, but a staff in one length is preferable for rough use, if it has not to be transported from one place to another; but of whatever description of mechanical arrangement the staff may partake, it is a great desideratum that it present to the observer a clear, simple, graduated face, upon which he can obtain for himself the reading of the quantities by the aid of his telescope.

The old-fashioned vane staves are so far gone out of use that it is not intended to notice them here.

Many levelling staves are figured by means of printed papers pasted or rather stuck on; but these are objectionable, as in wet weather the paper will, by constant use, rub off, and thus the utility of the staff is at once destroyed.

Levelling surveyors, who paint their own staves, have varied fancies as to the method of doing it; all first divide the staff into feet and tenths, but some subdivide those tenths into actual hundredths. I have tried many ways, and will give the one my experience has led me to prefer. Fig. 173 represents this staff.

It will be observed, that the division of the feet is always readily distinguished by the top of the large figure which numbers the feet, and the bottom of the large figure is always ·85, consequently, the division of the ·90 always crosses the large figure at $\frac{1}{3}$rd of its length, and the ·80 is always a little below the foot of it. ·75 is marked by a red line, which differs from the ·25 in this particular, that one crosses the staff in a plain white space, while the other crosses through one of the black blocks. ·70 is exactly at the top of the block, immediately below the distinctive mark of ·75, and ·60 is the mark intervening between ·70 and ·50, which latter is represented by the top of the letter V; ·40 is the bottom of the V, and ·30 is next above the distinctive mark of ·25, as ·20 is next below it. ·10 is readily distinguished as next above the preceding

figure denoting the number of feet, and thus completes a very simple, and at the same time, a very bold and distinctly marked staff, clearly legible in dull weather, and about the subdivision of which to hundredths there is no difficulty whatever to a practised eye, and no chance of error beyond a hundredth at most to an unpractised one. The absence of all other figures than those numbering the feet render the mistake of one figure for another impossible, and while there are doubtless many as good, it is confidently believed few are better.

The operation of levelling is performed in this simple way—a staff is held up at the two places between which the difference of level is required, and if the reading on one staff is more than that on the other, the difference between them is the difference of level, or the measure by which the distance of one from the earth's centre exceeds that of the other. We have already seen that within a distance of 10 chains from the level there is no correction required for curvature and refraction, and, consequently, no level should be taken beyond this distance from the instrument. It is hardly necessary to mention this, for very few instruments, unless too large and cumbersome for ordinary requirements, will read a staff distinctly at a greater distance.

Let figure 173*a* represent a section of the surface between two points A and G, the difference of level between which is required.

Set up the instrument at B, and read a staff at A; reverse the telescope, and read a staff at C. Remove the instrument to D; get another reading from the same staff at C, and from a fresh staff at E; again remove the instrument to F, and get readings from E and G. Now, it is evident from what has been said, that the sum of the back readings, minus the sum of the fore readings, is the difference of level required; and to avoid negative quantities, we will assume the point A is 20 feet above an imaginary level plane, which we call our Datum line. The calculation stands thus:—

	FEET.
Height of A above datum	20 ·
Add reading of staff A	11 · 50
	31 · 50
Deduct fore reading of staff C	11 · 90
Gives the height of C above datum	19 · 60
Add back reading of C as taken at D	12 · 20
	31 · 80

	31 · 80
Deduct fore reading of E taken at D	8 · 46
Height of E above datum	23 · 34
Add back reading of E taken at F	7 · 64
	30 · 98
Deduct fore reading of G taken at F	7 · 98
Height of G above datum	23 · 00

A being 20 above datum, and G being 23, G is obviously 3 feet higher than A. It will however be seen, that the highest point is E, which is 23·34 above datum, and consequently, 0·34 above G; C is 19·60 feet above datum, or 0·40 feet below A.

In actual practice, the adding and subtracting the back and fore readings is never (or at all events by very few surveyors) carried out in detail, in the manner which, for the sake of explicitness, it has been given above. It is obvious, that if the difference of level between two staves be added when the fore reading is the lesser, or subtracted when it is greater, it will produce the same result—for example, the difference of level between A and C is 0·40 feet, and the back sight being the lesser height if that is subtracted from the datum at A, it will give the height of C, and so on throughout the series.

There are several forms of levelling books in use among surveyors, but they only differ as to the position and number of the vertical columns; it will be only necessary for me to describe one of these forms.

Taking our preceding example then, the annexed is a specimen of the practical reduction of it in a Field Book.

Levels taken from A *to* G.

Distances.	Back Sights.	Fore Sights.	Rise.	Fall.	Reduced Levels.	Remarks.
Links						Datum line 20 ft. below A
	20.		20.		20.	Station A.
800	11.50	11.90		.40	19.60	,, C.
1500	12.20	8.46	3.74	—	23.34	,, E.
2000	7.64	7.98	—	.34	23.	,, G.
	51.34	28.34	23.74	.74		
	28.34		.74			
	23.		23.			

Very few remarks will serve to render this form of Field Book intelligible. Distances have been inserted to shew the use of the column headed distances; but in many cases distances are not taken in levelling.

The datum line is first fully described in the column of remarks. The height above datum is then placed in the column of reduced levels, as the height of station A; and it is also repeated in the columns headed "back sights," and "rise," for the purposes of the proof of the casting, as will be hereafter seen. The back sight * at A, and the fore sight at C, are now placed side by side in their respective columns, and their difference placed in the proper column of "rise" or "fall," as the case may be. In like manner the back sight at C, and the fore sight at E, are entered, and so on throughout the series. The rises are now added to the preceding height above datum, and the falls deducted and the results shew the respective heights of each station.

The method of keeping a Field Book admits of two proofs. First—If the sum of the fore sights is deducted from the sum of the back sights, including the first height above datum, it will give the relative height of the last station, and should consequently correspond with the last item of reduced levels. In like manner if the sum of the falls be deducted from the sum of the rises, including the first height above datum, it will, if correct, produce the same result.

Attention to a few trifling circumstances in levelling will secure most important results. If the level is always placed perfectly central between two stations, the results will always be correct irrespective of any instrumental error. If it is sometimes necessary to have a long back sight and a short fore sight, it is always practicable to reverse the order within a station or two, so that the back sights and fore sights are made to balance. Never get a reading from a staff without first observing that the bubble of the spirit tube is in the centre of its run; nor ever leave a staff after the reading until it has been entered in the book, and has been again examined. If accuracy is not of less importance than expedition never use a staff as a rule, that is more than about ten feet long; it is all very well to have an extra length for exceptional cases, but the best staff holder will not keep a long staff perpendicular. It should be borne in mind, that errors of this description are not, as is often the case in instrumental errors, capable of balancing themselves by being sometimes of a positive,

* That is, the reading of the staff.

and at others, of a negative character, and thus standing a chance of accidental adjustment. If a staff is not held perpendicular, the error must always be that the reading observed is too much, the perpendicular distance between any two points being always the shortest distance possible.

Of course, if the same error exists in both back and fore reading it is immaterial. But the use of these long staves is only brought into action in descending or rising a hill, when one reading is nearly zero, while the other is perhaps fifteen feet up the staff. There is one chance of a balance with errors of this kind—and it is in cases when the ascents and descents are equal; a circumstance against which the odds are very great. The staff holders should always be provided with something to stand the staff upon, to ensure the reversal of the staff between the readings from the different stations of the instrument with mathematical precision. A penny, or a small piece of tile or slate is better than nothing, but far preferable to that, is what is called a "tripod." This little instrument consists of a triangular piece of sheet iron of about an eighth of an inch thick, shod at the corners to enter the ground; and a semi-circular ball is rivetted on to the top, so that whatever the position of tripod or staff, the latter is certain to be placed on the same spot, notwithstanding any removal in the interim between the first and last reading. A small chain, with a ring or leather strap attached, enables the staff holder to lift it from the ground, and carry it from station to station without inconvenience.

If any intermediate readings occur, that is, points of which it is competent to ascertain the level without moving the instrument to do it; the most simple method is to treat the fore sight of the intermediate as a fresh back sight, and re-enter it as such; but in proving the castings these need not be cast in with the others, but such as occur in both columns can of course be cancelled. I subjoin one practical example.

Distances	Back Sight.	Fore Sight.	Rise.	Fall.	Reduced Levels.	Remarks.
	100.		100.		100.	Datum line 100 feet below the stone sill of the south door to Wandsworth old Church, in the High Street, close against the middle of the door-post on the east side of the door.
	3.79	* 4.05		.26	99.74	B. M. on stone sill of gate.
000	* 4.05	4.96		.91	98.83	Centre of High Street.
600	4.28	2.09	2.19		101.02	
1000	3.33	4.05		.72	100.30	
1600	5.76	3.19	2.57		102.87	
2100	7.44	* 0.45	6.99		109.86	B. M. on stone at corner of North Street.
	* 0.45	0.23	·22		110.08	Junction of High Street and North Street.
2300	7.84	1.52	6.32		116.40	
2500	8.99	1.40	7.59		123.99	
2700	9.18	1.33	7.85		131.84	
3000	9.84	1.55	8.29		140.13	
3600	9.93	1.84	8.09		148.22	
3800	6.64	* 4.46	2.18		150.40	Fork of Vauxhall and Clapham Roads.
4400	* 4.46	2.69	1.77		152.17	
	5.77	* 4.01	1.76		153.93	B. M. on top of hanging post of gate into East Hill burying ground, from the Vauxhall Road.
4650	* 4.01	6.27		2.26	151.67	
5000	2.09	5.71		3.62	148.05	
6000	6.10	3.78	2.32		150.37	
7000	5.32	5.84		.52	149.85	
7870	3.60	* 1.00	2.60		152.45	B. M. on top of coping of bridge over S. W. Railway—on the south side of bridge immediately over the near side down rail (about 27.25 above rail).
1 mile	* **1.00**	**7.05**		**6.05**	**146.40**	
750	1.66	* 6.66		5.00	141.40	
1000	* 6.66	12.20		5.54	135.86*	*Road leads off to Tooting.
1400	1.17	12.53		11.36	124.50	
1800	0.10	10.46		10.36	114.14	
2100	1.86	* 7.34		5.48	108.66	
2480	* 7.34	0.31	7.03		115.69	
2720	9.04	0.56	8.48		124.17	
2950	8.48	0.21	8.27		132.44	
3300	9.24	1.58	7.66		140.10	
	9.24	* 6.76	2.48		142.58	B. M. on the top of the guard stone to western gate post at entrance to a gentleman's house, south of road.
4300	* 6.76	1.46	5.30		147.88	
5300	7.43	5.87	1.56		149.44	
6300	5.80	5.10	.70		150.14	
7000	4.80	5.18		.38	149.76	
2 miles	**4.59**	**4.37**	**.22**		**149.98**	**Clapham Common.**
1000	4.67	5.54		.87	149.11	
1200	5.35	4.44	.91		150.02	
1209	4.75	0.24	4.51		154.53	B. M. on the top of mile stone marked by the Ordnance Officers.—Five Miles from Standard, Cornhill.
2000	3.10	6.02		2.92	151.61	
3000	6.16	6.95		.79	150.82	
4000	5.61	2.26	3.35		154.17	Junction with Dorking Road.
5000	4.05	6.53		2.48	151.69	
6000	2.54	9.28		6.74	144.95	
	299.54	154.59	211.21	66.26		
	154.59		66.26			
	144.95		144.95			

Distances	Back Sight.	Fore Sight.	Rise.	Fall.	Reduced Levels.	Remarks.
	144.95		144.95		144.95	
6450	2.07	* 3.91		1.84	143.11	B. M on top of milestone, marked 3 miles from Westminster Bridge.
6500	* 3.91	8.98		5.07	138.04	
7000	1.80	9.30		7.50	130·54	
7500	.95	7.17		6.22	124.32	
3 miles	**6.09**	**3.22**	**2.87**		**127.19**	
300	7.37	* 3.74	3.63		130.82	
1000	* 3.74	8.44		4.70	126.12	
	0.63	1.14		.51	125.61	B. M. on top of water plug, opposite St. John's Chapel and the Elms.
2000	1.14	12.58		11·44	114.17	
3000	0.82	7.97		7.15	107.02	
	4.52	* 0.68	3.84		110.86	B. M. on top of milestone, marked three miles from Blackfriars.
4000	* 0.68	7.81		7.13	103.73	
5000	6.10	6.58		.48	103.25	
6000	5.13	6.95		1.82	101.43	
6450	5.51	* 1.88	3.63		105.06	B. M. on top of milestone, marked two miles from Westminster Bridge.
7000	* 1.88	5.66		3.78	101.28	
7400	4.57	2.14	2.43		103.71	B. M. on top of milestone, at corner of Albert Square.
4 miles	**2.14**	**6.85**		**4.71**	**99.00**	
1000	5.00	6.67		1.67	97.33	
2000	6.31	5.39	.92		98.25	
2500	7.90	* 5.35	2.55		100.80	Opposite the Griffin Inn.
3000	* 5.35	8.77		3.42	97.38	
3830	4.16	* 2.65	1.51		98.89	B. M. on top of lower hook of T. P. Gate, next Toll House, on Kennington Common.
4000	* 2.65	5.77		3.12	95.77	
5000	4.27	6.67		2.40	93.37	
6000	5.10	5.50		·40	92.97	
7000	5.94	6.21		.27	92.70	
5 miles	**4.09**	**4.23**		**.14**	**92.56**	
1000	4.21	2.82	1.39		93.95	
1300	5.87	* 3.32	2.55		96.50	B. M. on top of Iron Water Post, on North Side of Street facing the Newington Registry Office for Servants.
2000	*3.32	6.46		3.14	93.36	
3000	3.67	66.6		2.99	90.37	
3600	7.33	* 3.24	4.09		94.46	Centre of Roads at the Elephant and Castle.
	* 3.24	0.45	2.79		97.25	B. M. on the top of a milestone facing the Shop of Connelly, Stationer, &c.
	257.64	160.39	177.15	79.90		
	160.39		79.90			
	97.25		97.2			

Note.—It will be observed that the intermediate sets are cancelled and omitted in the cast up of the pages.

CHAPTER IX.

PLOTTING.

THE first consideration in plotting is the choice of the paper upon which to lay down the survey that has been made. In large surveys it is often desirable to lay down the fundamental lines to a very small scale (twenty or thirty chains to an inch), from which to arrive at a tolerably correct notion of the size of the paper required, and the most eligible position thereon for the principal line.

The Officers of the Ordnance Survey have laid it down as a standing rule always to keep the north of the map towards the top of the paper; but I do not regard this as an essential feature, especially in original maps. I would at any time sacrifice it to the attainment of a more eligible position of the map upon the paper. I do not mean to say I would reverse the order of things, and place the south towards the top, but I certainly should not mind so placing the east or west. As an instance of my meaning, the survey of the parish of Horsell, hereinbefore referred to, required paper about ten feet long by five wide, the length being in the direction of east and west. To place such a map north upwards would be to render what might be comparatively a handy roll of five feet long, an unhandy one of ten feet, which few ordinary tables in private houses would accommodate. Having selected the position of the main line on the paper, the next thing is to lay it down. This must be done with a straight edge proportioned to its length, as it is a very difficult thing to produce a line by means of several splicings—a "*steel* straight edge" will be found desirable for this purpose. As soon as the line is down, the distances from zero at every ten chains along its course should be marked off according to the scale with which the work is to be plotted; this should be done with the point of a needle, and the figures denoting the number of chains should be very finely marked against the several dots. The number of the line should then be placed on the end at which the measurement of it commences, which answers the double purpose of being an index to the line, and the direction in which it ran. All future distances on the line laid down will be laid off from the nearest dot, without reference to the zero of the line, so that any inaccuracy arising from expansion or contraction of the paper will be obviated as much as possible.

It is generally less difficult to lay down the first line of a survey than it is the second and third, inasmuch as the true position of the

latter as sides of a triangle have to be scrupulously attended to. In large surveys it is often necessary to resort to a variety of mathematical contrivances to get them down accurately; sometimes the use of a thread or a slip of mounted drawing paper marked the required length from the main line will scribe an arc tolerably near, but it is always safer and generally more correct to adopt the best means at once, and do it mathematically. A simple process is to compute the angles accurately, and then with any convenient length as radius, say 100 chains, find the natural sine and cosine by the Table. Let fig. 174 represent this method. Suppose the triangle A D G to be a trigonometrical projection required to be plotted, whose sides are beyond the limits of all drawing tables—straight edges and scales at command. Lay off the cosine of angle A from A to B, and of angle D from D to C. Erect perpendiculars at B and C; lay off the sine of angle A from B to F, and of angle D from C to E; try that A F and D E are exactly equal to the radius of 100 chains, and E and F may then be used as points from which to raise G; F G and E G having now become in all probability within manageable compass. The points E and F may be sometimes better fixed by scribing the radius and sine—much depends upon the angle. If a perpendicular is erected, it must be a really accurate one; and if the work is very extensive, it will be as well to calculate mathematically the length of E F. The point G obtained, the straightness of the lines A F G and D E G must be tested with the straight edge; but if the operation has been carefully performed, there is little probability but that they will prove correct. As every line is plotted, the distances from zero should be marked off at each ten chains, as on the main line, and the line numbered as before directed. As many of the fundamental lines as possible should be laid down at one time, so that in the event of subsequent alteration of paper, which is almost certain to take place, all the work may go together, and but the minimum of inconvenience experienced.

In laying down the secondary lines of the survey, such as the line R I, on the parish of Sunbury survey, having drawn the line from point to point with the straight edge, previous to marking off the furlongs, try the length on the paper, and compare it with the book, for with the most careful chaining there is at all times a liability to disagreement, owing to the unevenness of the ground over, and the hedges and other places through, which the chain has to pass. This disagreement, for it is not error, should in no case exceed about a link in ten chains on an average of the whole length of the line, and should be equally spread in plotting throughout

the whole length—that is, a line entered in the Field Book a 20005 may measure on the paper 20025, and yet be practically correct; but it would be manifestly inaccurate to point off 200 chains 25 links from the end of the line. In such a case, 10 chains must be plotted as 1001; 2000 as 2002; 3000 as 3003, &c. When all the lines are down (and if expedient drawn in very finely with carmine or lake) the offsets can be plotted. Until tolerable skill has been acquired by considerable practice, every point should be carefully pricked off with a needle upon the chain line, and the offset therefrom accurately marked off; but after a time it will be sufficient to expedite the business by any contrivance that may suggest itself, and in the absence of a better, let us suppose the following:—Lay the edge of the plotting scale A B (fig. 175) parallel with the line C D, upon which the offsets are to be plotted, at such a distance that the zero division of the offset scale E may coincide with the line as it passes along it, and also that zero on scale A B may be exactly opposite the zero end of the line; then, by sliding the offset scale along the line any offset not exceeding a chain in length (which, as has been already said in another place, should be the maximum limit of the offset, and should also be the maximum space between the chain line and scale) may be accurately plotted on either side of the line.

To Plot the Notes of a Traverse Survey by the Table of Natural Sines and Cosines.

The only difference between plotting the notes of a traverse and any other survey consists in laying down the lines. In the case of our previous example (fig. 170) we will assume that the trigonometrical points A B C are already plotted. With the aid of the Table of Natural Sines and Cosines, lay off the angle between A B and the magnetic meridian in the following manner:—

A and B (fig. 176) are the two stations of the survey, whose bearing is taken.

Take 1, 10, or 100 in the compasses, according to the extent of the lines, and scribe the arc E F: produce A B, so that A D shall be equal to the cosine, and D F the sine of the given angle: join A F, and it will be the required meridian.

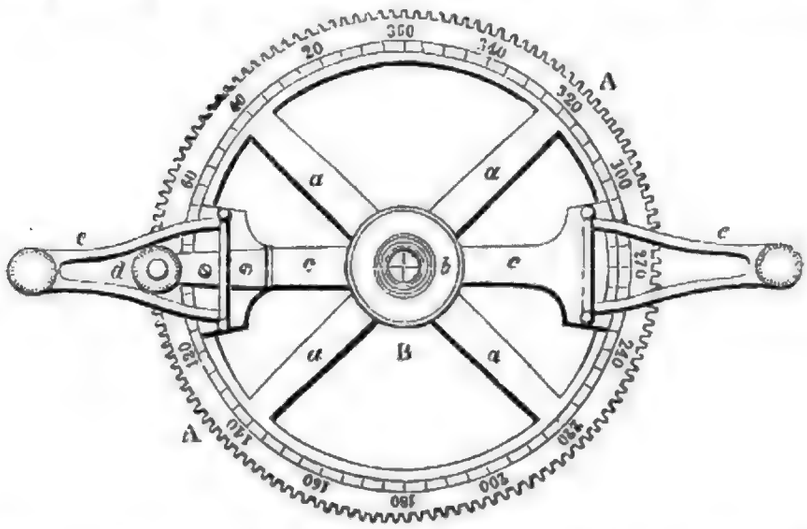
In like manner, line 1 is laid down by means of the angle contained between it and the magnetic meridian, its length is then marked off from A, and a line drawn through the end of it parallel to the meridian from which line 2 is marked off; and so on throughout the series.

The great objection to traverse surveying, as a means of *filling in*, is the opportunity afforded for error in every line. It is obvious, that a link too much or too little in laying down each line will prevent the work from closing at the end; hence, the great advantage of a system of right lines, which renders every one independent of another.

As the method of laying down the lines of a traverse by means of their sines and cosines may be considered troublesome in a survey of magnitude, a protractor, or circular instrument of brass, may be employed to facilitate the laying off the angles.

THE CIRCULAR PROTRACTOR.

Our engraving represents one of the best kind of protractors.



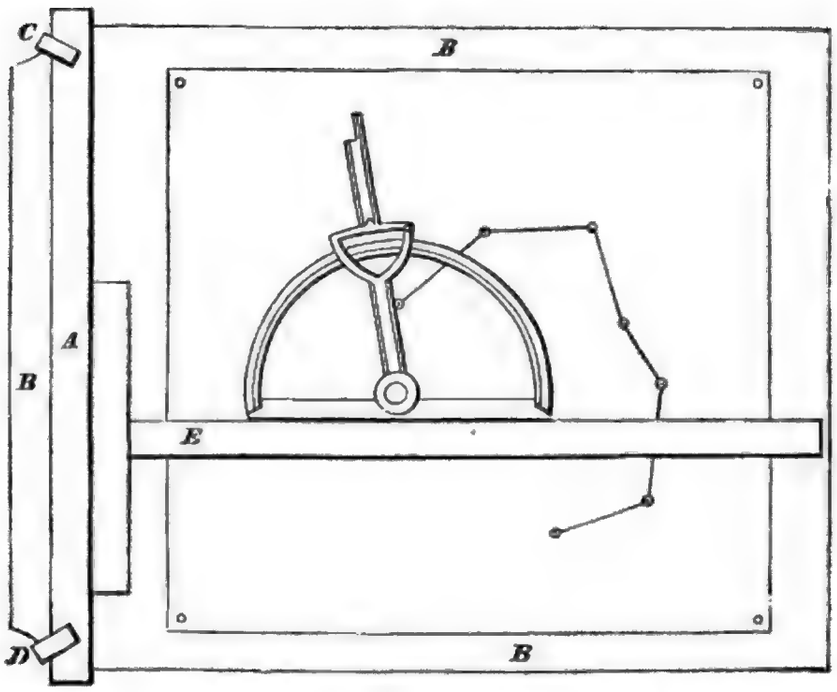
It is a complete circle, A A, connected with its centre by four radii, *a a a a*. The centre is left open, and surrounded by a concentric ring or collar, *b*, which carries two radial bars, *c c*. To the extremity of one bar is a pinion, *d*, working in a toothed rack quite round the outer circumference of the protractor: to the opposite extremity of the other bar, *c*, is fixed a vernier, which subdivides the primary divisions on the protractor to single minutes, and by estimation to 30 seconds. This vernier, as may readily be understood from the engraving, is carried round the protractor by turning the pinion *d*. Upon each radial bar, *c c*, is placed a branch *e e*, carrying at their extremities a fine steel pricker, whose points are kept above the surface of the paper by springs placed under their supports, which give way when the branches are pressed downwards, and allow the points to make the necessary punctures in the paper. The branches *e e* are attached to the bars *c c*, with a joint which admits of their being folded backwards over the instrument when not in use, and for

packing in its case. The centre of the instrument is represented by the intersection of two lines drawn at right angles to each other on a piece of plate glass, which enables the person using it to place it, so that the centre, or intersection of the cross lines, may coincide with any given point on the plan. If the instrument is in correct order, a line connecting the fine pricking points with each other would pass through the centre of the instrument, as denoted by the before-mentioned intersection of the cross lines upon the glass, which, it may be observed, are drawn so nearly level with the under surface of the instrument, as to do away with any serious amount of parallax, when setting the instrument over a point from which any angular lines are intended to be drawn. In using this instrument, the vernier should first be set to zero (or the division marked 360) on the divided limb, and then placed on the paper, so that the two fine steel points may be on the given line (from whence other and angular lines are to be drawn), and the centre of the instrument coincides with the given angular point on such line. This done, press the protractor gently down, which will fix it in position by means of very fine points on the under side. It is now ready to lay off the given angle, or any number of angles that may be required, which is done by turning the pinion *d* till the opposite vernier reads the required angle. Then press downwards the branches *e e*, which will cause the points to make punctures in the paper at opposite sides of the circle; which being afterwards connected, the line will pass through the given angular point, if the instrument was first correctly set. In this manner, at one setting of the instrument, a great number of angles may be laid off from the same point.

It is not essential that the centre be over the given point when applied to the given line, provided the pricking points exactly fall upon the line, for an imaginary line connecting the pricking points in this instrument, correspond with the diameter. Sometimes, instead of a rack and pinion motion, a third radial arm is attached to the centre at right angles to the other two, upon which is fixed a clamp and tangent screw, by which the vernier is not only fixed in position upon the circular limb of the instrument, but by the tangent, or slow motion screw, it may be set to the required angle with the utmost precision.

THE T SQUARE AND SEMI-CIRCULAR PROTRACTOR.

A convenient method by which a traverse can be most expeditiously as well as accurately plotted, by the aid of a T square



and semi-circular protractor, is thus described by Mr. Howlett, chief draughtsman, Royal Ordnance Office, in vol. i. of Papers on Subjects connected with the Duties of the Royal Engineers:—

"As, when away from home, it seldom happens that the surveyor can obtain a good drawing board, or even a table with a good straight edge, I fix a flat ruler, A, to the table B B B, by means of a pair of clamps, C D, and against this ruler I work the pattern square E, one side of which has the stock flush with the blade; or, if a straight-edged board be at hand, then the square may be turned over, and used against that edge instead of the ruler A. Here, then, is the most perfect kind of parallel ruler that art can produce, capable of carrying the protractor over the whole of a sheet of plotting paper of any size, and may be used upon a table of any form. It is convenient to suppose the north on the left hand, and the upper edge of the blade to represent the meridian of the station.

"This protractor is held in the hand while the vernier is set, which is an immense comfort to the sight; and it will be seen that, as both sides of the arm are parallel with the zero and centre, the angle may be drawn on the paper against either side, as the light or other circumstances may render desirable."

From this description and a mere glance at the engraving, it is clear that angles taken with the theodolite can be transferred to the plot as accurately as the protractor can be set, namely, to a single minute, and that, too, in a rapid and pleasant manner.

My own experience in plotting traverses as the "filling in" portions of a survey is not favourable to the use of a metallic protractor, I prefer making a protractor in the following manner:— With a radius of 10 inches describe a circle, and without altering the compasses step round the circle pointing each step; this will divide it into six parts, each being 60°. Now the chord of an arc

being equal to twice the sine of half that arc, if from the Table of Natural Sines we take the sine of 5° and multiply it by 2, we get the chord of 10°, which being laid off, subdivides each 60° into six parts of 10° each. In like manner we continue to subdivide the circle, until we have done so as minutely as required. Divisions, each containing five minutes, will be found quite small enough in practice, as lesser quantities are readily estimated by the eye. The degrees should then be numbered, as in a theodolite, and the protractor is fit for use.

The traverses of the Guernsey survey are plotted with a protractor of this kind, in the following manner:—Two trigonometrical stations that can be connected by a series of traverse lines are selected. A sheet of tracing paper is laid over the protractor, upon which the position of one of the points is marked. A straight edge is then laid across the protractor to correspond with the bearing of line 1, and by means of two wooden set squares or triangles a parallel line is transferred to the point from which line 1 starts, where the line is drawn to its proper length, and the station marked for the commencement of line 2. The straight edge is then laid across the paper to correspond with the bearing of line 2, which is now marked off in its proper position parallel to the bearing. In like manner all the lines are plotted until they close upon another trigonometrical station. When the tracing paper is taken up, the two trigonometrical stations thereon are laid over the corresponding stations on the map, and the lines are transferred from the tracing thereto.

On working maps, it is customary to distinguish the dwelling-houses from other buildings, by tinting the former with carmine or lake, and the latter with neutral tint. The rivers and waters are also tinted blue, and the roads a light brown; any thing beyond this in the way of colouring amounts to a decoration which is not required. If the map is one of an estate or property, the names of the owners of the adjoining lands should be written in their respective positions; but if it is a parish map, the names of the adjoining parishes are substituted, as in plate 5. The names of all gentlemen's seats, farms, hamlets, and remarkable places, should be subscribed, and the whole should be invested with as much local interest as possible.

Every field or parcel of property should be distinguished by a separate reference number, by which it may be referred to from a book containing all particulars relating thereto, as well as the quantity of each field in statute measure.

The following are two specimens of reference books.

NUMERICAL REFERENCE.

Owner.	*Occupier.*	*No. on Plan.*	*Description.*	*Cultivation.*	*Quantity.* A. R. P.	*Remarks.*
Phipps, George . .	Ryde, Edward . . .	1	Barn Field	Arable	9 2 6	
Weale, John	Ryde, Edward . . .	2	Carthouse Field . .	Arable	6 1 30	
Weale, John	Ryde, Edward . . .	3	Garson Meadow . .	Grass	13 1 6	
Phipps, George . .	Donaldson, John .	4	Doomsday	Grass	9 1 30	
Weale, John	Ryde, Edward . . .	5	Garson Field	Arable	16 1 30	
Weale, John	Ryde, Edward . . .	6	High Holborn Farm	Homestead	1 1 10	
Phipps, George . .	Donaldson, John .	7	The Retreat	House & Garden .	1 3 20	
				Total Content . .	58 1 12	

COLLECTED REFERENCE.

Owner.	*Occupier.*	*No. on Plan.*	*Description.*	*Cultivation.*	*Quantity.* A. R. P.	*Remarks.*
Phipps, George ..	Ryde, Edward...	1	Barn Field	Arable	9 2 6	
Phipps, George ..	Donaldson, John .	4	Doomsday.....	Grass.....	9 1 30	
		7	The Retreat	House & Garden .	1 3 20	
					11 1 10	
Weale, John	Ryde, Edward...	2	Carthouse Field ..	Arable	6 1 30	
		3	Garson Meadow ..	Grass.....	13 1 6	
		5	Garson Field....	Arable	16 1 30	
		6	High Holborn Farm	Homestead	1 1 10	
					37 1 36	

COLLECTED REFERENCE.

SUMMARY.

Owner.	*Occupier.*	*Description.*	*Quantity in each Holding.*	*Total Quantity.*	*Remarks.*
Phipps, George . .	Ryde, Edward . . .	Land	9 2 6		
„ „	Donaldson, John .	House and Land .	11 1 10	20 3 16	
Weale, John	Ryde, Edward . . .	High Holborn Farm	37 1 36	37 1 36	
			Total Quantity .	58 1 12	

PLOTTING SECTIONS.

Plotting the notes from a level book is a very simple process. First draw the datum line an indefinite length near the bottom of the paper, then mark off all the distances along the line at which a level has been taken; at each one of which erect a perpendicular line in pencil; mark off the vertical height above datum upon each of these perpendicular lines; connect the points after the manner of plotting a fence by offsets from a chain line, and the section is complete. It is not usual to use the same scale vertically and horizontally; the former requiring to be much larger than the latter. Plate 11 represents a "Working Section" of a Railway.

CHAPTER X.

COMPUTATION OF AREAS.

THE method of computing the areas of fields by arithmetical calculation, has been of late years superseded by the introduction of two very ingenious little instruments called respectively the "Pediometer," and the "Computing Scale."* These instruments obviate calculation, economise time, and diminish the liability to error. I will describe them both; but the "Computing Scale" is the one used by civil surveyors.

Description of the Pediometer.

The instrument consists of a square, and a graduated scale, constructed for three chains to the inch.

a—The milled head, by turning which, motion is given to the brass slider B, and the two pointers R and W.

I—The index to be placed in coincidence with the ► division upon the scale.

When the brass slider B is in contact with A, I coinciding with ► division, and R and W pointing to O upon their respective scales, the instrument is in adjustment.

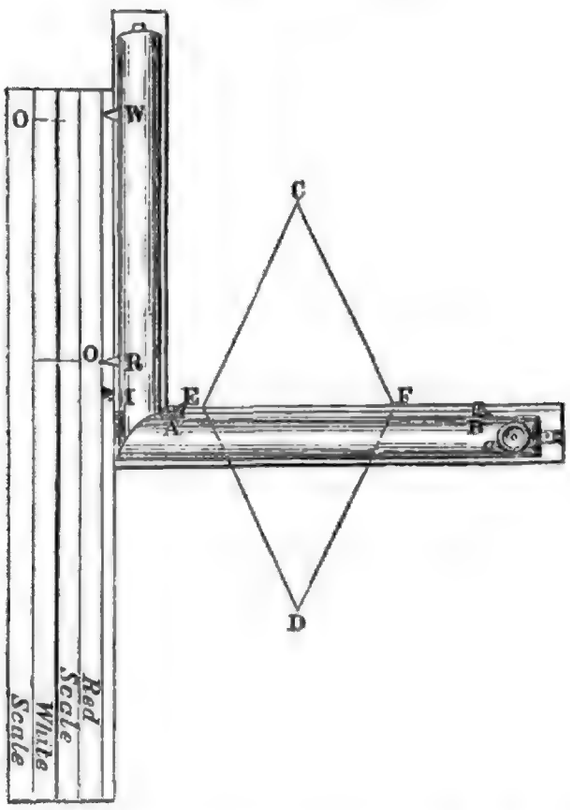
When deranged, restore it, by opening R and W to the proper distance, and then moving A and I, the former into contact with B, and the latter into coincidence with ► .

Required the content of the trapezium E C F D.

1st.—Place the edge A upon the point E, and open B to the point F.

* By some the "*Tithe* Computing Scale," simply because it was first introduced for the "First Class Maps at the Tithe Office."

THE PEDIOMETER.



2nd.—Press the square firmly down with the right hand, and with the left place the scale against the edge of it, as shewn in the figure.

3rd.—Now press the scale firmly, and slide the square *up*, until the edge A B is upon the point C.

4th.—Press the square firmly, and slide the scale against its edge until ► coincides with I.

Finally.—Press the scale and slide the square *down* until the edge A B is upon the point D, and taking out the numbers to which W and R point, subtract the latter from the former, and the contents in acres and decimal parts of an acre will at once be given.

The red pointer directs to the numbers that are to be taken from the red scale, and the white one to those upon the white scale.

When the pointers fall exactly upon the line engraved on the ivory edge of the scale, the folding leaf is to be doubled down to the left hand; but when the pointers fall between any two of the lines on the ivory edge, the folding leaf must then be doubled over to the right hand before the numbers are read off.

For instance, when the leaf is turned to the left and the red

pointer falls between the two lines which refer to ·008 and ·013, turn the folding leaf to the right hand, and the pointer will read 0·10.

It will be found most convenient and most accurate in practice to take the shortest diagonal for the line E F.

THE COMPUTING SCALE.

This instrument answers the same purpose of giving mechanically the contents of enclosures as the Pediometer, but is more simple in its construction and principle of operation.

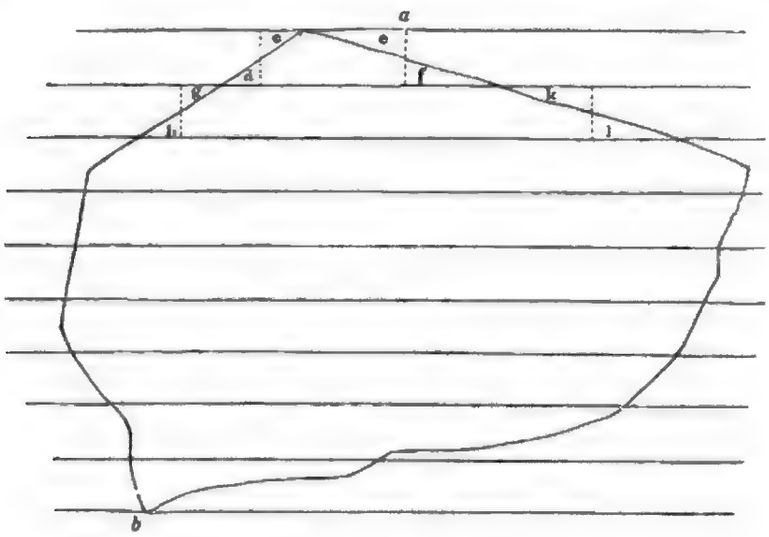
It consists of a scale divided for its whole length from the zero point into divisions, each representing 2½ *chains*, and is used with a sheet of transparent tracing paper, ruled with parallel lines at equidistant intervals of one *chain*.



The slider B, which moves along the scale, has a wire drawn across its centre at right angles to its line of motion; and on each side of this wire a distance equal to one of the primary divisions of 2½ chains is laid off, and divided into 40 parts. It is evident, then, that during the passage of the slider over one of the divisions of 2½ chains, *one rood* has been measured between two of the parallel lines on the tracing paper; and that one of the smaller divisions would measure between the same parallels *one perch*. Four of the larger divisions giving *one acre*; and the scale itself generally made long enough to measure at once five acres, is thus used: Lay the transparent paper over the enclosure the content of which is required, in such a position that two of the ruled lines shall touch two of the exterior points of the boundaries, as at *a* and *b*.

Lay the scale, with the slider set to zero, over the tracing paper, in a direction parallel to the lines, and so placed that the portions *c* and *d* are estimated by the eye as equal to each other. Holding the scale steady, move on the sliding frame until the equality of the portions *e* and *f* are also estimated. With the slider kept at this mark, move the scale bodily down the space of one of the ruled lines (one chain), and commencing again at the left hand, estimate the equal areas of *g* and *h*, sliding the frame on to *k* and *l*. When the whole length of the scale, denoting 5 acres, is run out, commence at the right-hand side, and work backwards to the left,

reading the lower divisions, by which the instrument is made to measure up to 10 acres. By a continuation of this process, the



contents of any sized enclosures can be obtained without calculation, and with a degree of accuracy proportionate to the amount of skill and care exercised on the equalization of the boundaries. Where the wire of the slider coincides with any portion of the boundary between two of the parallels no *equalization* is of course necessary.

Explanation of the following Tables.

The use of the following Tables will be obvious at first sight. If the area of a plan plotted to a scale of two chains to an inch be computed with a three-chain computing scale, seek the result or the the next smaller number thereto, in the column headed "Three Chains," and immediately adjoining, viz., in that headed "Two Chains," is the correct acreage. If the result by the three-chain scale is more than 9 acres, it must be taken at twice, that being the limit of the Tables.

The Tables have been so constructed as to exhibit the nearest relative equivalent to the results given; for instance, 7 . 1 . 10 on a three-chain scale is exactly equal to 3 . 1 . 0 on a two; but then 7 . 1 . 9 is also nearer thereto than to 3 . 0 . 39; and hence 7 . 1 . 9 is placed as the equivalent. Again, 9 . 0 . 0 (three-chain scale) is exactly equivalent to 1 . 0 . 0 (one-chain scale); but as 8 . 3 . 36 is also nearer thereto than to 0 . 3 . 39, that is stated as the three-chain equivalent.

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
0	0	2=0	0	1	
0	0	4=0	0	2	
0	0	6=0	0	3	
0	0	8=0	0	4	
0	0	11=0	0	5	
0	0	13=0	0	6	
0	0	15=0	0	7	
0	0	17=0	0	8	
0	0	20=0	0	9	
0	0	22=0	0	10	
0	0	24=0	0	11	
0	0	26=0	0	12	
0	0	29=0	0	13	
0	0	31=0	0	14	
0	0	33=0	0	15	
0	0	35=0	0	16	
0	0	38=0	0	17	
0	1	0=0	0	18	
0	1	2=0	0	19	
0	1	4=0	0	20	
0	1	7=0	0	21	
0	1	9=0	0	22	
0	1	11=0	0	23	
0	1	13=0	0	24	
0	1	16=0	0	25	
0	1	18=0	0	26	
0	1	20=0	0	27	
0	1	22=0	0	28	
0	1	25=0	0	29	
0	1	27=0	0	30	
0	1	29=0	0	31	
0	1	31=0	0	32	
0	1	34=0	0	33	
0	1	36=0	0	34	
0	1	38=0	0	35	
0	2	0=0	0	36	
0	2	3=0	0	37	
0	2	5=0	0	38	
0	2	7=0	0	39	
0	2	9=0	1	0	

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
0	2	12=0	1	1	
0	2	14=0	1	2	
0	2	16=0	1	3	
0	2	18=0	1	4	
0	2	21=0	1	5	
0	2	23=0	1	6	
0	2	25=0	1	7	
0	2	27=0	1	8	
0	2	30=0	1	9	
0	2	32=0	1	10	
0	2	34=0	1	11	
0	2	36=0	1	12	
0	2	39=0	1	13	
0	3	1=0	1	14	
0	3	3=0	1	15	
0	3	5=0	1	16	
0	3	8=0	1	17	
0	3	10=0	1	18	
0	3	12=0	1	19	
0	3	14=0	1	20	
0	3	17=0	1	21	
0	3	19=0	1	22	
0	3	21=0	1	23	
0	3	23=0	1	24	
0	3	26=0	1	25	
0	3	28=0	1	26	
0	3	30=0	1	27	
0	3	32=0	1	28	
0	3	35=0	1	29	
0	3	37=0	1	30	
0	3	39=0	1	31	
1	0	1=0	1	32	
1	0	4=0	1	33	
1	0	6=0	1	34	
1	0	8=0	1	35	
1	0	10=0	1	36	
1	0	13=0	1	37	
1	0	15=0	1	38	
1	0	17=0	1	39	
1	0	19=0	2	0	

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
1	0	22=0	2	1	
1	0	24=0	2	2	
1	0	26=0	2	3	
1	0	28=0	2	4	
1	0	31=0	2	5	
1	0	33=0	2	6	
1	0	35=0	2	7	
1	0	37=0	2	8	
1	1	0=0	2	9	
1	1	2=0	2	10	
1	1	4=0	2	11	
1	1	6=0	2	12	
1	1	9=0	2	13	
1	1	11=0	2	14	
1	1	13=0	2	15	
1	1	15=0	2	16	
1	1	18=0	2	17	
1	1	20=0	2	18	
1	1	22=0	2	19	
1	1	24=0	2	20	
1	1	27=0	2	21	
1	1	29=0	2	22	
1	1	31=0	2	23	
1	1	33=0	2	24	
1	1	36=0	2	25	
1	1	38=0	2	26	
1	2	0=0	2	27	
1	2	2=0	2	28	
1	2	5=0	2	29	
1	2	7=0	2	30	
1	2	9=0	2	31	
1	2	11=0	2	32	
1	2	14=0	2	33	
1	2	16=0	2	34	
1	2	18=0	2	35	
1	2	20=0	2	36	
1	2	23=0	2	37	
1	2	25=0	2	38	
1	2	27=0	2	39	
1	2	29=0	3	0	

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
1	2	32=0	3	1	
1	2	34=0	3	2	
1	2	36=0	3	3	
1	2	38=0	3	4	
1	3	1=0	3	5	
1	3	3=0	3	6	
1	3	5=0	3	7	
1	3	7=0	3	8	
1	3	10=0	3	9	
1	3	12=0	3	10	
1	3	14=0	3	11	
1	3	16=0	3	12	
1	3	19=0	3	13	
1	3	21=0	3	14	
1	3	23=0	3	15	
1	3	25=0	3	16	
1	3	28=0	3	17	
1	3	30=0	3	18	
1	3	32=0	3	19	
1	3	34=0	3	20	
1	3	37=0	3	21	
1	3	39=0	3	22	
2	0	1=0	3	23	
2	0	3=0	3	24	
2	0	6=0	3	25	
2	0	8=0	3	26	
2	0	10=0	3	27	
2	0	12=0	3	28	
2	0	15=0	3	29	
2	0	17=0	3	30	
2	0	19=0	3	31	
2	0	21=0	3	32	
2	0	24=0	3	33	
2	0	26=0	3	34	
2	0	28=0	3	35	
2	0	30=0	3	36	
2	0	33=0	3	37	
2	0	35=0	3	38	
2	0	37=0	3	39	
2	0	39=1	0	0	

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
2	1	2=1	0	1	
2	1	4=1	0	2	
2	1	6=1	0	3	
2	1	8=1	0	4	
2	1	11=1	0	5	
2	1	13=1	0	6	
2	1	15=1	0	7	
2	1	17=1	0	8	
2	1	20=1	0	9	
2	1	22=1	0	10	
2	1	24=1	0	11	
2	1	26=1	0	12	
2	1	29=1	0	13	
2	1	31=1	0	14	
2	1	33=1	0	15	
2	1	35=1	0	16	
2	1	38=1	0	17	
2	2	0=1	0	18	
2	2	2=1	0	19	
2	2	4=1	0	20	
2	2	7=1	0	21	
2	2	9=1	0	22	
2	2	11=1	0	23	
2	2	13=1	0	24	
2	2	16=1	0	25	
2	2	18=1	0	26	
2	2	20=1	0	27	
2	2	22=1	0	28	
2	2	25=1	0	29	
2	2	27=1	0	30	
2	2	29=1	0	31	
2	2	31=1	0	32	
2	2	34=1	0	33	
2	2	36=1	0	34	
2	2	38=1	0	35	
2	3	0=1	0	36	
2	3	3=1	0	37	
2	3	5=1	0	38	
2	3	7=1	0	39	
2	3	9=1	1	0	

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
2	3	12=1	1	1	
2	3	14=1	1	2	
2	3	16=1	1	3	
2	3	18=1	1	4	
2	3	21=1	1	5	
2	3	23=1	1	6	
2	3	25=1	1	7	
2	3	27=1	1	8	
2	3	30=1	1	9	
2	3	32=1	1	10	
2	3	34=1	1	11	
2	3	36=1	1	12	
2	3	39=1	1	13	
3	0	1=1	1	14	
3	0	3=1	1	15	
3	0	5=1	1	16	
3	0	8=1	1	17	
3	0	10=1	1	18	
3	0	12=1	1	19	
3	0	14=1	1	20	
3	0	17=1	1	21	
3	0	19=1	1	22	
3	0	21=1	1	23	
3	0	23=1	1	24	
3	0	26=1	1	25	
3	0	28=1	1	26	
3	0	30=1	1	27	
3	0	32=1	1	28	
3	0	35=1	1	29	
3	0	37=1	1	30	
3	0	39=1	1	31	
3	1	1=1	1	32	
3	1	4=1	1	33	
3	1	6=1	1	34	
3	1	8=1	1	35	
3	1	10=1	1	36	
3	1	13=1	1	37	
3	1	15=1	1	38	
3	1	17=1	1	39	
3	1	19=1	2	0	

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
3	1	22=1	2	1	
3	1	24=1	2	2	
3	1	26=1	2	3	
3	1	28=1	2	4	
3	1	31=1	2	5	
3	1	33=1	2	6	
3	1	35=1	2	7	
3	1	37=1	2	8	
3	2	0=1	2	9	
3	2	2=1	2	10	
3	2	4=1	2	11	
3	2	6=1	2	12	
3	2	9=1	2	13	
3	2	11=1	2	14	
3	2	13=1	2	15	
3	2	15=1	2	16	
3	2	18=1	2	17	
3	2	20=1	2	18	
3	2	22=1	2	19	
3	2	24=1	2	20	
3	2	27=1	2	21	
3	2	29=1	2	22	
3	2	31=1	2	23	
3	2	33=1	2	24	
3	2	36=1	2	25	
3	2	38=1	2	26	
3	3	0=1	2	27	
3	3	2=1	2	28	
3	3	5=1	2	29	
3	3	7=1	2	30	
3	3	9=1	2	31	
3	3	11=1	2	32	
3	3	14=1	2	33	
3	3	16=1	2	34	
3	3	18=1	2	35	
3	3	20=1	2	36	
3	3	23=1	2	37	
3	3	25=1	2	38	
3	3	27=1	2	39	
3	3	29=1	3	0	

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
3	3	32=1	3	1	
3	3	34=1	3	2	
3	3	36=1	3	3	
3	3	38=1	3	4	
4	0	1=1	3	5	
4	0	3=1	3	6	
4	0	5=1	3	7	
4	0	7=1	3	8	
4	0	10=1	3	9	
4	0	12=1	3	10	
4	0	14=1	3	11	
4	0	16=1	3	12	
4	0	19=1	3	13	
4	0	21=1	3	14	
4	0	23=1	3	15	
4	0	25=1	3	16	
4	0	28=1	3	17	
4	0	30=1	3	18	
4	0	32=1	3	19	
4	0	34=1	3	20	
4	0	37=1	3	21	
4	0	39=1	3	22	
4	1	1=1	3	23	
4	1	3=1	3	24	
4	1	6=1	3	25	
4	1	8=1	3	26	
4	1	10=1	3	27	
4	1	12=1	3	28	
4	1	15=1	3	29	
4	1	17=1	3	30	
4	1	19=1	3	31	
4	1	21=1	3	32	
4	1	24=1	3	33	
4	1	26=1	3	34	
4	1	28=1	3	35	
4	1	30=1	3	36	
4	1	33=1	3	37	
4	1	35=1	3	38	
4	1	37=1	3	39	
4	1	39=2	0	0	

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
4	2	2	2	0	1
4	2	4	2	0	2
4	2	6	2	0	3
4	2	8	2	0	4
4	2	11	2	0	5
4	2	13	2	0	6
4	2	15	2	0	7
4	2	17	2	0	8
4	2	20	2	0	9
4	2	22	2	0	10
4	2	24	2	0	11
4	2	26	2	0	12
4	2	29	2	0	13
4	2	31	2	0	14
4	2	33	2	0	15
4	2	35	2	0	16
4	2	38	2	0	17
4	3	0	2	0	18
4	3	2	2	0	19
4	3	4	2	0	20
4	3	7	2	0	21
4	3	9	2	0	22
4	3	11	2	0	23
4	3	13	2	0	24
4	3	16	2	0	25
4	3	18	2	0	26
4	3	20	2	0	27
4	3	22	2	0	28
4	3	25	2	0	29
4	3	27	2	0	30
4	3	29	2	0	31
4	3	31	2	0	32
4	3	34	2	0	33
4	3	36	2	0	34
4	3	38	2	0	35
5	0	0	2	0	36
5	0	3	2	0	37
5	0	5	2	0	38
5	0	7	2	0	39
5	0	9	2	1	0

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
5	0	12	2	1	1
5	0	14	2	1	2
5	0	16	2	1	3
5	0	18	2	1	4
5	0	21	2	1	5
5	0	23	2	1	6
5	0	25	2	1	7
5	0	27	2	1	8
5	0	30	2	1	9
5	0	32	2	1	10
5	0	34	2	1	11
5	0	36	2	1	12
5	0	39	2	1	13
5	1	1	2	1	14
5	1	3	2	1	15
5	1	5	2	1	16
5	1	8	2	1	17
5	1	10	2	1	18
5	1	12	2	1	19
5	1	14	2	1	20
5	1	17	2	1	21
5	1	19	2	1	22
5	1	21	2	1	23
5	1	23	2	1	24
5	1	26	2	1	25
5	1	28	2	1	26
5	1	30	2	1	27
5	1	32	2	1	28
5	1	35	2	1	29
5	1	37	2	1	30
5	1	39	2	1	31
5	2	1	2	1	32
5	2	4	2	1	33
5	2	6	2	1	34
5	2	8	2	1	35
5	2	10	2	1	36
5	2	13	2	1	37
5	2	15	2	1	38
5	2	17	2	1	39
5	2	19	2	2	0

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
5	2	22	2	2	1
5	2	24	2	2	2
5	2	26	2	2	3
5	2	28	2	2	4
5	2	31	2	2	5
5	2	33	2	2	6
5	2	35	2	2	7
5	2	37	2	2	8
5	3	0	2	2	9
5	3	2	2	2	10
5	3	4	2	2	11
5	3	6	2	2	12
5	3	9	2	2	13
5	3	11	2	2	14
5	3	13	2	2	15
5	3	15	2	2	16
5	3	18	2	2	17
5	3	20	2	2	18
5	3	22	2	2	19
5	3	24	2	2	20
5	3	27	2	2	21
5	3	29	2	2	22
5	3	31	2	2	23
5	3	33	2	2	24
5	3	36	2	2	25
5	3	38	2	2	26
6	0	0	2	2	27
6	0	2	2	2	28
6	0	5	2	2	29
6	0	7	2	2	30
6	0	9	2	2	31
6	0	11	2	2	32
6	0	14	2	2	33
6	0	16	2	2	34
6	0	18	2	2	35
6	0	20	2	2	36
6	0	23	2	2	37
6	0	25	2	2	38
6	0	27	2	2	39
6	0	29	2	3	0

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
6	0	32	2	3	1
6	0	34	2	3	2
6	0	36	2	3	3
6	0	38	2	3	4
6	1	1	2	3	5
6	1	3	2	3	6
6	1	5	2	3	7
6	1	7	2	3	8
6	1	10	2	3	9
6	1	12	2	3	10
6	1	14	2	3	11
6	1	16	2	3	12
6	1	19	2	3	13
6	1	21	2	3	14
6	1	23	2	3	15
6	1	25	2	3	16
6	1	28	2	3	17
6	1	30	2	3	18
6	1	32	2	3	19
6	1	34	2	3	20
6	1	37	2	3	21
6	1	39	2	3	22
6	2	1	2	3	23
6	2	3	2	3	24
6	2	6	2	3	25
6	2	8	2	3	26
6	2	10	2	3	27
6	2	12	2	3	28
6	2	15	2	3	29
6	2	17	2	3	30
6	2	19	2	3	31
6	2	21	2	3	32
6	2	24	2	3	33
6	2	26	2	3	34
6	2	28	2	3	35
6	2	30	2	3	36
6	2	33	2	3	37
6	2	35	2	3	38
6	2	37	2	3	39
6	2	39	3	0	0

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
6	3	2=3	0	1	
6	3	4=3	0	2	
6	3	6=3	0	3	
6	3	8=3	0	4	
6	3	11=3	0	5	
6	3	13=3	0	6	
6	3	15=3	0	7	
6	3	17=3	0	8	
6	3	20=3	0	9	
6	3	22=3	0	10	
6	3	24=3	0	11	
6	3	26=3	0	12	
6	3	29=3	0	13	
6	3	31=3	0	14	
6	3	33=3	0	15	
6	3	35=3	0	16	
6	3	38=3	0	17	
7	0	0=3	0	18	
7	0	2=3	0	19	
7	0	4=3	0	20	
7	0	7=3	0	21	
7	0	9=3	0	22	
7	0	11=3	0	23	
7	0	13=3	0	24	
7	0	16=3	0	25	
7	0	18=3	0	26	
7	0	20=3	0	27	
7	0	22=3	0	28	
7	0	25=3	0	29	
7	0	27=3	0	30	
7	0	29=3	0	31	
7	0	31=3	0	32	
7	0	34=3	0	33	
7	0	36=3	0	34	
7	0	38=3	0	35	
7	1	0=3	0	36	
7	1	3=3	0	37	
7	1	5=3	0	38	
7	1	7=3	0	39	
7	1	9=3	1	0	

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
7	1	12=3	1	1	
7	1	14=3	1	2	
7	1	16=3	1	3	
7	1	18=3	1	4	
7	1	21=3	1	5	
7	1	23=3	1	6	
7	1	25=3	1	7	
7	1	27=3	1	8	
7	1	30=3	1	9	
7	1	32=3	1	10	
7	1	34=3	1	11	
7	1	36=3	1	12	
7	1	39=3	1	13	
7	2	1=3	1	14	
7	2	3=3	1	15	
7	2	5=3	1	16	
7	2	8=3	1	17	
7	2	10=3	1	18	
7	2	12=3	1	19	
7	2	14=3	1	20	
7	2	17=3	1	21	
7	2	19=3	1	22	
7	2	21=3	1	23	
7	2	23=3	1	24	
7	2	26=3	1	25	
7	2	28=3	1	26	
7	2	30=3	1	27	
7	2	32=3	1	28	
7	2	35=3	1	29	
7	2	37=3	1	30	
7	2	39=3	1	31	
7	3	1=3	1	32	
7	3	4=3	1	33	
7	3	6=3	1	34	
7	3	8=3	1	35	
7	3	10=3	1	36	
7	3	13=3	1	37	
7	3	15=3	1	38	
7	3	17=3	1	39	
7	3	19=3	2	0	

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
7	3	22=3	2	1	
7	3	24=3	2	2	
7	3	26=3	2	3	
7	3	28=3	2	4	
7	3	31=3	2	5	
7	3	33=3	2	6	
7	3	35=3	2	7	
7	3	37=3	2	8	
8	0	0=3	2	9	
8	0	2=3	2	10	
8	0	4=3	2	11	
8	0	6=3	2	12	
8	0	9=3	2	13	
8	0	11=3	2	14	
8	0	13=3	2	15	
8	0	15=3	2	16	
8	0	18=3	2	17	
8	0	20=3	2	18	
8	0	22=3	2	19	
8	0	24=3	2	20	
8	0	27=3	2	21	
8	0	29=3	2	22	
8	0	31=3	2	23	
8	0	33=3	2	24	
8	0	36=3	2	25	
8	0	38=3	2	26	
8	1	0=3	2	27	
8	1	2=3	2	28	
8	1	5=3	2	29	
8	1	7=3	2	30	
8	1	9=3	2	31	
8	1	11=3	2	32	
8	1	14=3	2	33	
8	1	16=3	2	34	
8	1	18=3	2	35	
8	1	20=3	2	36	
8	1	23=3	2	37	
8	1	25=3	2	38	
8	1	27=3	2	39	
8	1	29=3	3	0	

3-Chain Scale.			2-Chain Scale.		
A.	R.	P.	A.	R.	P.
8	1	32=3	3	1	
8	1	34=3	3	2	
8	1	36=3	3	3	
8	1	38=3	3	4	
8	2	1=3	3	5	
8	2	3=3	3	6	
8	2	5=3	3	7	
8	2	7=3	3	8	
8	2	10=3	3	9	
8	2	12=3	3	10	
8	2	14=3	3	11	
8	2	16=3	3	12	
8	2	19=3	3	13	
8	2	21=3	3	14	
8	2	23=3	3	15	
8	2	25=3	3	16	
8	2	28=3	3	17	
8	2	30=3	3	18	
8	2	32=3	3	19	
8	2	34=3	3	20	
8	2	37=3	3	21	
8	2	39=3	3	22	
8	3	1=3	3	23	
8	3	3=3	3	24	
8	3	6=3	3	25	
8	3	8=3	3	26	
8	3	10=3	3	27	
8	3	12=3	3	28	
8	3	15=3	3	29	
8	3	17=3	3	30	
8	3	19=3	3	31	
8	3	21=3	3	32	
8	3	24=3	3	33	
8	3	26=3	3	34	
8	3	28=3	3	35	
8	3	30=3	3	36	
8	3	33=3	3	37	
8	3	35=3	3	38	
8	3	37=3	3	39	
9	0	0=4	0	0	

3-Chain Scale.			1-Chain Scale.		
A.	R.	P.	A.	R.	P.
0	0	5	0	0	1
0	0	14	0	0	2
0	0	23	0	0	3
0	0	32	0	0	4
0	1	1	0	0	5
0	1	10	0	0	6
0	1	19	0	0	7
0	1	28	0	0	8
0	1	37	0	0	9
0	2	6	0	0	10
0	2	15	0	0	11
0	2	24	0	0	12
0	2	33	0	0	13
0	3	2	0	0	14
0	3	11	0	0	15
0	3	20	0	0	16
0	3	29	0	0	17
0	3	38	0	0	18
1	0	7	0	0	19
1	0	16	0	0	20
1	0	25	0	0	21
1	0	34	0	0	22
1	1	3	0	0	23
1	1	12	0	0	24
1	1	21	0	0	25
1	1	30	0	0	26
1	1	39	0	0	27
1	2	8	0	0	28
1	2	17	0	0	29
1	2	26	0	0	30
1	2	35	0	0	31
1	3	4	0	0	32
1	3	13	0	0	33
1	3	22	0	0	34
1	3	31	0	0	35
2	0	0	0	0	36
2	0	9	0	0	37
2	0	18	0	0	38
2	0	27	0	0	39
2	0	36	1	0	0

3-Chain Scale.			1-Chain Scale.		
A.	R.	P.	A.	R.	P.
2	1	5	0	1	1
2	1	14	0	1	2
2	1	23	0	1	3
2	1	32	0	1	4
2	2	1	0	1	5
2	2	10	0	1	6
2	2	19	0	1	7
2	2	28	0	1	8
2	2	37	0	1	9
2	3	6	0	1	10
2	3	15	0	1	11
2	3	24	0	1	12
2	3	33	0	1	13
3	0	2	0	1	14
3	0	11	0	1	15
3	0	20	0	1	16
3	0	29	0	1	17
3	0	38	0	1	18
3	1	7	0	1	19
3	1	16	0	1	20
3	1	25	0	1	21
3	1	34	0	1	22
3	2	3	0	1	23
3	2	12	0	1	24
3	2	21	0	1	25
3	2	30	0	1	26
3	2	39	0	1	27
3	3	8	0	1	28
3	3	17	0	1	29
3	3	26	0	1	30
3	3	35	0	1	31
4	0	4	0	1	32
4	0	13	0	1	33
4	0	22	0	1	34
4	0	31	0	1	35
4	1	0	0	1	36
4	1	9	0	1	37
4	1	18	0	1	38
4	1	27	0	1	39
4	1	36	0	2	0

3-Chain Scale.			1-Chain Scale.		
A.	R.	P.	A.	R.	P.
4	2	5	0	2	1
4	2	14	0	2	2
4	2	23	0	2	3
4	2	32	0	2	4
4	3	1	0	2	5
4	3	10	0	2	6
4	3	19	0	2	7
4	3	28	0	2	8
4	3	37	0	2	9
5	0	6	0	2	10
5	0	15	0	2	11
5	0	24	0	2	12
5	0	33	0	2	13
5	1	2	0	2	14
5	1	11	0	2	15
5	1	20	0	2	16
5	1	29	0	2	17
5	1	38	0	2	18
5	2	7	0	2	19
5	2	16	0	2	20
5	2	25	0	2	21
5	2	34	0	2	22
5	3	3	0	2	23
5	3	12	0	2	24
5	3	21	0	2	25
5	3	30	0	2	26
5	3	39	0	2	27
6	0	8	0	2	28
6	0	17	0	2	29
6	0	26	0	2	30
6	0	35	0	2	31
6	1	4	0	2	32
6	1	13	0	2	33
6	1	22	0	2	34
6	1	31	0	2	35
6	2	0	0	2	36
6	2	9	0	2	37
6	2	18	0	2	38
6	2	27	0	2	39
6	2	36	0	3	0

3-Chain Scale.			1-Chain Scale.		
A.	R.	P.	A.	R.	P.
6	3	5	0	3	1
6	3	14	0	3	2
6	3	23	0	3	3
6	3	32	0	3	4
7	0	1	0	3	5
7	0	10	0	3	6
7	0	19	0	3	7
7	0	28	0	3	8
7	0	37	0	3	9
7	1	6	0	3	10
7	1	15	0	3	11
7	1	24	0	3	12
7	1	33	0	3	13
7	2	2	0	3	14
7	2	11	0	3	15
7	2	20	0	3	16
7	2	29	0	3	17
7	2	38	0	3	18
7	3	7	0	3	19
7	3	16	0	3	20
7	3	25	0	3	21
7	3	34	0	3	22
8	0	3	0	3	23
8	0	12	0	3	24
8	0	21	0	3	25
8	0	30	0	3	26
8	0	39	0	3	27
8	1	8	0	3	28
8	1	17	0	3	29
8	1	26	0	3	30
8	1	35	0	3	31
8	2	4	0	3	32
8	2	13	0	3	33
8	2	22	0	3	34
8	2	31	0	3	35
8	3	0	0	3	36
8	3	9	0	3	37
8	3	18	0	3	38
8	3	27	0	3	39
8	3	36	1	0	0

CHAPTER XI.

COPYING MAPS.

VARIOUS methods, according to circumstances, are resorted to for multiplying Copies of Maps; two only, which are the most usual, will be mentioned here. To copy a map by "*pricking it off*," lay the original over the paper intended for the copy, and with a very fine needle prick through every point at which a change takes place in the relative position of the lines of the plan; connect all these points by lines similar to those of the original, and a fair duplicate plan will be obtained. Plans copied in this manner generally answer to scale better, that is, are more nearly accurate in general features than any other duplicate maps; but the details are apt to get distorted in minute peculiarities, notwithstanding the greatest amount of care and attention. One very great disadvantage also is, the impossibility of placing the original again over the copy in the same position after it has been once removed, so as to enable any omission to be supplied.

In pricking off maps there are a few things to be attended to, to secure success. The needle should always be held perfectly erect, so that the impression may be directly under the point on the original. In narrow parallel lines, such as a river, brook, or road, a dot should not be pricked on one side without pricking one immediately opposite it in the line forming the other side, by which means confusion of the dots in drawing the lines of the copy is avoided. All straight lines should have a dot in the centre, as well as at either end, both as an additional precaution to ensure accuracy, and also to afford a means of identifying the dots with the lines. Many other things will suggest themselves with practice that would occupy more space than can be appropriated here.

To Copy a Map by means of "Transferring Paper."—Get a sheet of thin paper, and rub over it some powdered black lead—the palm of the hand is the best thing to rub this black lead on with; and when it has been well rubbed in, a rough cloth should be passed over it to get off as much of the superfluous lead as possible, so that it may not wipe off upon the map. Place the black side towards the paper that is to receive the copy of the plan, and put the original upon the whole; then with a blunt steel point or

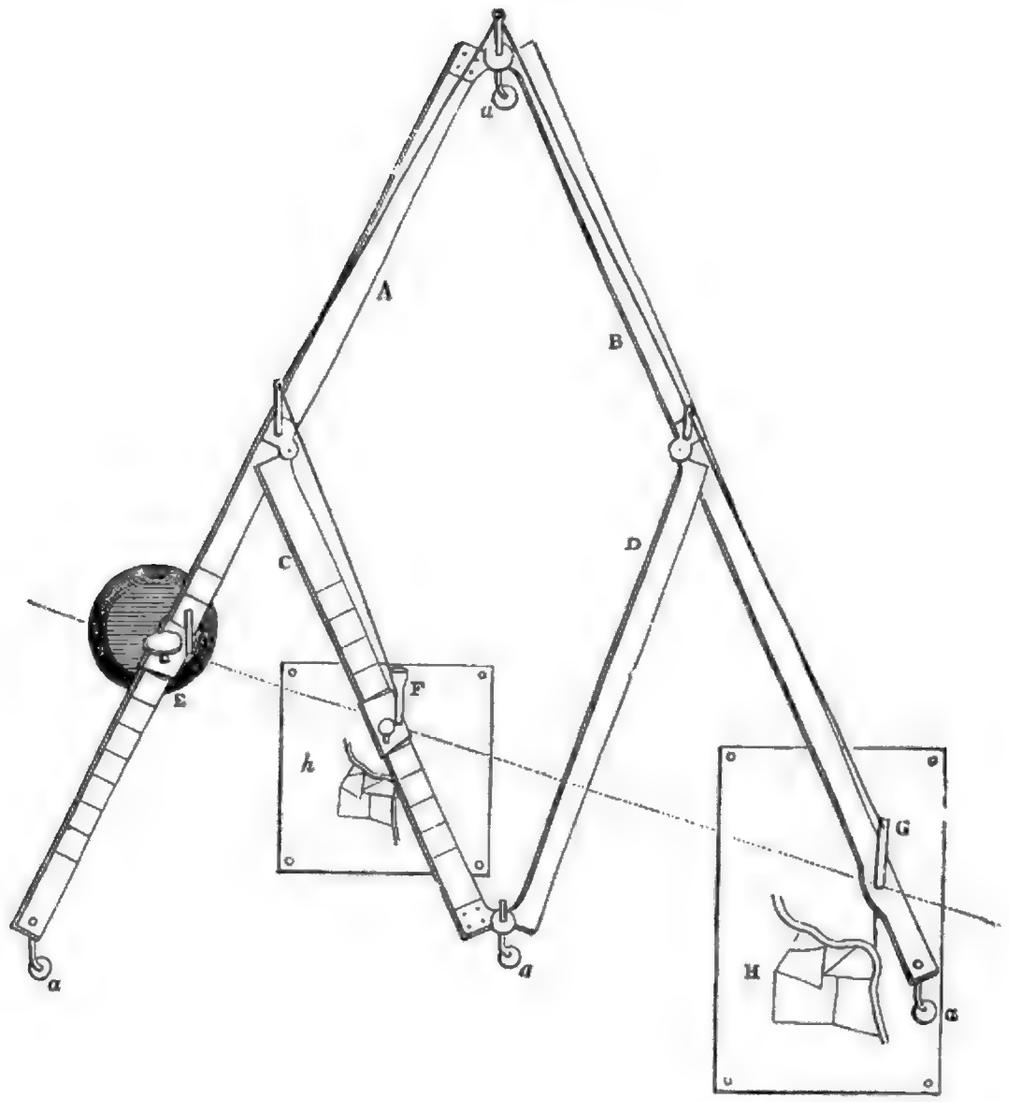
tracer go over all the lines of the original, and the pressure of the tracer will cause the black lead to come off upon the under paper, and thus delineate a *fac-simile* of the original. We may as well consider at once, that a tracing will first have to be taken from the original, as the paper upon which plans are plotted is in the generality of cases in practice, much too thick to admit of a transfer being made direct from it with any accuracy, or at all events without spoiling the original, which is at all times a thing worth any trouble in the avoiding.

Plans may also be copied by the Pentagraph, an instrument which next claims our attention.

THE PENTAGRAPH.

This is an instrument but very imperfectly understood, even by those who are most frequently using it. It requires to be very accurately constructed and skilfully handled, and then very beautiful work will be the result. Its chief use is to reduce or enlarge plans, but it will also copy the same size. In describing the use of the Pentagraph, we may as well confine our attention to the reduction of maps, as work cannot be enlarged with any degree of satisfaction; small unappreciable errors are magnified into important ones, and the whole features become distorted. With reduction on the contrary, errors of all kinds are reduced in magnitude, and many entirely disappear.

This instrument is represented in the annexed engraving, where it is shewn as in the act of copying a plan H, upon a reduced scale *h*. The Pentagraph consists of four rulers, A, B, C, and D, made of stout brass. The two longer rulers, A and B, are connected together by, and have a motion round a centre, shewn at the upper part of the engraving. The two shorter rulers are, in like manner, connected with each other, and with the longer rulers, as may be clearly understood from an inspection of the engraving. The whole instrument is supported by small pillars resting upon ivory rollers, *a a a*, &c., which have a motion in all directions exactly like the brass castors fixed to ordinary tables. The rulers A and C have each an equal number of similar divisions, marked $\frac{1}{4}$, $\frac{1}{2}$, &c.; and likewise a sliding index, E and F, which can be fixed to any divisions on the ruler by a milled-headed clamp screw shewn in the engraving. The sliding indeces, E and F, have each of them a tube adapted to slide on a pin, rising from a heavy circular weight called the fulcrum, which acts as a centre for the whole instrument to turn upon when in use, or to receive a sliding holder with a pencil, or a tracing point, as may be required.



Our fig. represents the instrument. The principle will at once become apparent. The bars B and C must always remain parallel to each other under every position of the instrument, as well as A and D. E F G are all in one straight line. Hence, two similar triangles are formed, whose sides are to each other as E F is to E G. By securing the point E in one spot, and by moving a tracer at G over the lines of the original, a pencil at F, left to follow the course of the instrument, will describe an exactly similar line, bearing the same proportion to the original as E F does to E G.

The Pentagraph is usually constructed in brass, with steel centres, and travels parallel to the paper, supported by the six ivory-mounted wheels. The pencil, in the best made instruments, is fixed in a case, something like the point of an ever-pointed Mordan pencil, by which contrivance the point is always in the centre. A small silken thread passes round the instrument from the pencil to the tracer, by means of which the pencil is caught up when it is re-

quired to move the instrument across the plan in a direction that is not required to be delineated. The bars A and C are generally divided, but it is not at all necessary they should be so, as the *ipse dixit* of the maker should never be taken for granted, and the instrument is easily set. Say, as the length in inches and decimals of any line upon the large map required to be reduced, is to the length of the bar B; so is the length to which the same line is required to be reduced to the proper length on the bar C. Again, as the difference in length of the line upon the large and small scale is to the length of that part of the bar A, between the bars C and B, so is the length of the line on the large map to the whole length of the bar A; or on the small map to that part of the bar A, between the bar C and the fulcrum. See that E F and G are in the same straight line and the instrument is set for use.

While the scale of the reduced map is required to be as small as, or smaller than, one-half of the original, the position of the fulcrum will be somewhere on the bar A; but when the proportion of the small map to the original becomes such as 3 to 5, 6 to 9, 10 to 12, &c., then the fulcrum and pencil must exchange places, and the proportion is calculated as E F to F G.

An inspection of the instrument, and a very little practice, will suggest all other explanation.

CHAPTER XII.

RAILWAY SURVEYING.

SECT. I.—*Exploration and Trial Levels.*

THE services of an engineer or surveyor, in connection with a projected line of railway, commence with what is technically termed an "exploration of the country," through which it is desirable or intended that it should pass. This exploration is a general examination of the district by the engineer for the purpose of making himself thoroughly acquainted with its geographical contour, and geological features. He then, by the aid of an Ordnance Map, if the line is situated in the south of England, or in Ireland, where such a map is obtainable, sketches out a line, over which he causes what are called "Trial Levels" to be taken. These Trial Levels are frequently but very rough affairs, but care should be always observed that the right point is taken at the crossing of all public

roads, and B M should be frequently noted, as a check upon the levels of any future process.

In taking Trial Levels, it is generally the custom, in critical localities, to level one or two alternative lines, but I would suggest, that one line with a number of cross sections at frequent intervals is more convenient, and affords a greater amount of useful information. The use of the "Exploration" is palpable; and the utility of the Trial Levels and Section must be obvious upon a very little consideration. By their aid the most favourable gradients can be selected, and even the absolute practicability of the railway in the proposed direction can be determined. It not unfrequently happens, in selecting the route for a line of railway, that a slight detour from the most direct course will save a long heavy embankment, or a deep cutting, and will moreover improve the gradients to a very great extent. Practice and experience will, as in most other things connected with the profession of an engineer or surveyor, be the only sure guides to success, in selecting the gradients and determining the mode of overcoming the difficulties presented by the face of the section. As a general rule, however, the cuttings should balance the embankments, so that the stuff taken out of the one may serve to create the other; but if it is necessary that one should predominate, I would in most cases give a preference to the latter, it being generally more easy to obtain a piece of side cutting than to carry to spoil* a large amount of superabundant earth.

When railways were more in their infancy easy gradients were insisted upon, and an inclination of 1 in 100 was thought as a rule sufficiently steep; but now that locomotive science and the whole subject are becoming more practically known, inclines of 1 in 80, 1 in 70, and 1 in 60, are to be frequently found on the sections of new and branch lines. All of which is of course but a question of expediency, between present economy of construction and the future expense of working the line.

The following is a brief extract of some of the requirements of the Standing Orders of the two Houses of Parliament, so far as they relate to the preliminary, or, as it is technically termed, "Parliamentary Survey" for an intended railway†.

* Banks formed of surplus excavated earths are called "Spoil Banks," and the earths so treated are said to be "carried to spoil."

† It is not intended to render service to the professional student, as he will find it expedient to procure a copy of the Standing Orders every successive session, in order that he may be fully acquainted with all amendments which from time to time may take place in them; but to the non-engineering enquirer this brief summary may contain all the information he is in search of.

Plan and Sections.

That a plan shall be drawn on a Scale of NOT LESS *than four inches to a mile*, and shall describe the line or situation of the whole work, and the lands in, or through which it is to be made, maintained, varied, extended, or enlarged, or through which every communication to or from the work shall be made.

When powers to make any lateral deviation from the line of the proposed work is intended to be applied for, the limits of such deviation shall be defined upon the plan, and all lands included within such limits to be marked thereon, and in all cases, excepting where the whole of such plan is upon a scale of not less than a quarter of an inch to every 100 feet, an additional plan of every building, yard, court-yard, or land within the curtilage of any building; or of any ground cultivated as a garden, either on the original line, or within the limits of the deviation, to be laid down on the plan, or on an additional plan to be deposited therewith, upon a scale of not less than a quarter of an inch to every 100 feet.

A section shall be drawn to the same horizontal scale as the plan, and to a vertical scale of not less than one inch to every 100 feet, which shall shew the surface of the ground marked on the plan, the intended level of the proposed work, and a datum horizontal line, which is to be the same throughout the whole length of the work, or any branch thereof respectively, and to be referred to some fixed point stated in writing on the section, near either of the termini.

The plan to exhibit thereon the distances in miles and furlongs from one of the termini, and a memorandum of the radius of every curve, not exceeding one mile in length, to be noted on the plan in furlongs and chains.

The line of railway marked upon the section to correspond with the upper surface of the rails.

The distances on the datum line to be marked in miles and furlongs to correspond with those on the plan, and a vertical measure from the datum line to the line of the railway to be marked in feet and inches at each change of the gradient or inclination, and the proportion or rate of inclination between each such change must also be marked.

The height of the railway over or under the surface of every turnpike road, public carriage road, navigable river, canal or

railway, or junction with a railway, and the height and span of every arch of all bridges and viaducts to be marked in figures at every crossing thereof, and the extreme height over or under the surface of the ground must be marked for every embankment and cutting; and if any alteration in the present level or rate of inclination of any turnpike road, carriage road, or railway, be intended, then the same to be stated on the section, and each numbered; also cross sections in reference to the same numbers on a horizontal scale of one inch to every 330 feet, and on a vertical scale of one inch to every 40 feet, to be added, to explain the nature of such alterations more clearly.

Where tunnelling as a substitute for open cutting, or a viaduct as a substitute for solid embankment, be intended, the tunnelling to be marked by a dotted line on the plan, and also to be marked on the section, and the viaduct to be marked on the section.

Deposit with the Clerk of the Peace.

Duplicate plans and sections, with a book of reference, to be deposited for public inspection at the Office of the Clerk of the Peace, for every county, riding, or division in England or Ireland, or in the Office of the principal Sheriff Clerk of every county in Scotland, in or through which the work is proposed to be made, maintained, varied, extended, or enlarged, on or before the 30th day of November, immediately preceding the session, in which application for the bill is to be made.

The Clerks of the Peace, or Sheriff Clerks, or their respective deputies, to mark in writing upon the plans, sections, and books of reference deposited with them, denoting the time at which the same are lodged in their respective offices, and at all seasonable hours of the day permit any person to view and examine one of the same, and to make copies or extracts therefrom; and one of the two plans deposited to be sealed up and retained in the possession of the Clerk of the Peace, or Sheriff Clerk, until called for, by order of one of the two Houses of Parliament.

Deposit at Board of Trade.

A copy of the Plans, Sections, and Books of Reference, to be deposited in the Office of the Railway Department of the Board of Trade, on or before the 30th of November, immediately preceding the Session of Parliament, in which application is to be made; together with a published map, to a scale of not less than

half an inch to a mile, with the line of railway delineated thereon, so as to shew its general course and direction.

Deposit with the Railway Commissioners.

That in the case of Railway Bills a copy of all Plans, Sections, and Books of Reference, required by the orders of the House to be deposited in the office of any Clerk of the Peace, or any Sheriff Clerk, on or before the 30th day of November preceding the application for the bill, together with a published map to a scale of not less than half an inch to a mile, with the line of railway delineated thereon, so as to shew its general course and direction, shall, on or before the same day, be deposited in the Office of the Commissioners of Railways.

Deposits at the Private Bill Office.

That on or before the 30th of November, a copy of the said Plan, Sections, and Books of Reference; and in the case of Railway Bills, also a copy of the said published map, with the line of railway delineated thereon, be deposited in the Private Bill Office of the House of Commons.

Deposit with Parish Clerks, &c.

A copy of so much of the plans and sections as relates to each parish in or through which the work is intended to be made, maintained, varied, extended, or enlarged, with a Book of Reference thereto, to be deposited on or before the 30th of November with the parish clerk of each such parish in England; the schoolmaster of each such parish in Scotland (or in the Royal Boroughs, with the Town Clerk), and the Clerk of the Union, within which such parish is included in Ireland.

When any lands or houses are intended to be taken, or an extension of the time granted by any former Act for that purpose, is sought, application in writing, in the form hereinafter set forth to be made to the owners, lessees, and occupiers, on or before the 15th day of December, which application must be delivered personally, or left at their usual place of abode; or in the event of their being absent from the United Kingdom, be left with their respective agents; and separate lists to be made of the names of such owners, lessees, or occupiers, distinguishing which of them have assented, dissented, or are neuter in respect thereto.

Lists of owners, lessees, and occupiers, to be lodged in the Private Bill Office, and the receipt thereof acknowledged on the petition before it is presented.

Notice in writing of a bill, whereby any part of a work authorised by any former Act is intended to be relinquished, to be given to the owners and occupiers of lands in which the part of the work intended to be thereby relinquished is situate.

Form of Notice to Owners, Lessees, and Occupiers.

SIR,—We beg to inform you that application is intended to be made to Parliament in the ensuing session for "An Act," [Here insert the title of the Act.] and that the property mentioned in the annexed schedule, or some part thereof, in which we understand you are interested, as therein stated, will be required for the purposes of the said undertaking, according to the line thereof as at present laid out, or may be required to be taken under the powers of deviation, which will be applied for in the said Act, and will be passed through in the manner mentioned in such Schedule.

We also beg to inform you, that on or before the 30th day of November last a plan and section of the proposed undertaking, and also a duplicate of such Plan and Section, together with a Book of Reference thereto, and also a copy of the notice published in the *London Gazette*, were deposited with the Clerk of the Peace for the county of ————, at his office in ————, in the said county; and that on or before the said 30th day of November last a copy of so much of the said plan and section as relates to the parish or parishes in which your property is situate, together with a Book of Reference to such plan, and also a copy of the notice published in the *London Gazette*, was also deposited with the parish clerk of each such parish, at his place of abode, on which plans your property is designated by the numbers set forth in the annexed Schedule.

As we are required to report to Parliament whether you assent to, or dissent from, the proposed undertaking, or whether you are neuter in respect thereto, you will oblige us by writing your answer of assent, dissent, or neutrality in the form left herewith, and returning the same to us, with your signature, on or before the — day of December instant; and if there should be any error or misdescription in the annexed Schedule, we shall feel obliged by your informing us thereof at your earliest convenience, that we may correct the same without delay.

We are, sir,

Your most obedient servants,

Schedule referred to in the foregoing Notice, describing the Property therein alluded to, and the manner in which the line of the proposed work, as delineated upon the plan and section, will affect the same.

Property in the line of the proposed work as at present laid out	Parish, Township, or extra parochial place.	No. on Plan.	Description.	Owner.	Lessee.	Occupier.	Description of the Section of the Line deposited, and of the greatest height of Embankment & depth of Cutting.			
							Embankment.		Cutting.	
							Feet.	Inches.	Feet.	Inches.
	Bigwood	194	Arable Land	The Rt. Hon. Wm. Eager.	John Smith Brown, Esq.	David Wilson	6	2		
	Smallcopse	391	Meadow Land	The same.	The same.	Felix Gregory			9	8
Property within the Limits of Deviation intended to be applied for.	**Parish, Township, Extra Parochial, or other place.**	**No. on Plan.**	**Description.**	**Owner.**	**Lessee.**	**Occupier.**				
	Bigwood	195	Arable Land	The Rt. Hon. Wm. Eager.	John Smith Brown, Esq.	David Wilson				
	Bigwood	196	Wood Land	The same	The same	The same				
	Smallcopse	392	Pasture Land The Moors	The same	The same.	Felix Gregory				

Preparation of Parliamentary Plans and Sections.

The Plans and Sections required by the Standing Orders of the Houses of Parliament, to be deposited at the Private Bill Office, and other places, on or before the 30th November, preceding the Session of Parliament, in which application is intended to be made for any powers in respect of works connected with such plans and sections, are generally very simple in construction to any one acquainted with surveying.

To describe a system which shall be best to adopt under all circumstances, would only serve to mislead, without being practicable. If the country to be surveyed is tolerably open, and the landowners and occupiers favourably disposed, it may be best to range a base line in the direction of the proposed railway, and thereon to build such other lines as may be necessary to take up the features of the country to a sufficient width on either side, care being taken in every change of base to cross the old and new bases a sufficient length beyond the junction, to admit the admeasurement of a tie line on either side. (See fig. 177.) And in plotting the distances A B, B C, C D, D B, B E, and A E, they should be tripled or quadrupled, as circumstances may admit, to enable their more accurate delineation on the map.

If the country is thick, and the landowners and occupiers not very friendly disposed, a traverse of the roads first made will much facilitate the work, as a base line cannot be ranged without cutting hedges, and nothing more exasperates a hostile farmer. A traverse of the nearest roads completed, the filling in, is a business that may be entrusted to a less experienced surveyor.

In the extract of the Standing Orders given herein, it will be observed, that the scale of the plans is required to be NOT LESS than four inches to a mile, which is twenty chains to an inch; but all buildings, gardens, &c., must be drawn to a scale NOT LESS than a quarter of an inch to every hundred feet, which is six chains and about six links to an inch.

Were not this latter condition necessary to a compliance with Standing Orders, most engineers would deposit plans to the smaller scale; not only because they would require less time in drawing, but also, and principally, because it would be far more difficult to detect any omission or error in them, upon which an alleged non-compliance might be founded. But the trouble of supplying all the requisite enlargements, and the danger of omitting some, has led to the almost universal adoption of a scale not less than six chains to an inch. Some engineers use a five-chain

scale for their plans, principally, because curves of any given number of furlongs, or half furlongs radius, can be drawn by curve rulers of some number of inches or half inches radius; independent of which, a five-chain scale is a very pretty one; but, as I have previously observed, the larger the scale, the greater is the facility for detecting an error; and, therefore, as these plans have generally to be prepared in a very great hurry, in the bad weather and short days of the month of November, circumstances favouring as much as possible the chances of error, the scale is generally kept as small as the regulations permit, obviating the enlargements.

When the plan is prepared, the course of the intended line is delineated thereon, and this is an operation requiring great care and circumspection. The trial section must be constantly consulted, in order that the cuttings and embankments may balance each other. Attention should also be given to the crossings of roads. If two roads fork in the vicinity of the line, so that they will each require to be crossed, an attempt should first be made to cross them at the fork, so that one bridge may serve the two; or, in the event of that being impracticable, a trial should be made to divert each road a little, so as by that means to effect the object of making one bridge serve the purpose.

A crooked river will very frequently traverse the same valley as an intended railway; and there, again, a little scheming in laying down the line on the map, may save the future expenditure of large sums of money in building bridges, which might be required were the line recklessly drawn.

Property possessing considerable local value, whether houses or land, should be avoided, if a slight curve will do so, without running into worse ground for the section; but if this latter contingency presents itself in opposition to the property, it will be found more economical, as a general rule, to pay for land than works.

When the line is drawn on the plan, the limits of deviation follow, either parallel thereto, or otherwise, as deemed expedient; then the line must be miled consecutively from one end to the other. A memorandum must be entered under each curve of its radius in furlongs and chains. The tunnels, if any, must be distinguished by a dotted line instead of a hard line; any diversion of roads or rivers must be drawn, the necessary writing and reference figures inserted, and then the plans are ready for deposit.

The plans completed, a section of the line will be carefully made, in manner explained under the head of Levelling; after which the Gradients must be determined.

Much diversity of opinion exists among engineers as to the ex-

pediency of making the attainment of easy gradients subservient to economical considerations; but without discussing that subject in this place, it may be observed, that our most eminent engineers of the present day are constantly laying out severe gradients, as well as curving lines, to save heavy cuttings and embankments—1 in 80 being a very common inclination, while in one case which has come under my notice in the present Session (1852-3,) 1 in 60 is laid out for a distance of upwards of six miles, with very little intermission.

It has been previously remarked, that cuttings and embankments should balance each other as nearly as may be, and that if a preponderancy exists, it should be of the latter rather than the former, by reason of the facility with which side cuttings can in most instances be resorted to. But other considerations present themselves.

It is at all times desirable to affect as little as possible the existing levels of public roads; an attempt should therefore be made either to cross them on a level*, or to pass 20 feet above or below them. It is decidedly advisable, if practicable, to lay out an ascending gradient from either way of the line towards a terminus, station, or junction point. Such a gradient not only serves to check the speed of a train when approaching such a point, but it also assists it on its way when leaving. The nearer we can fulfil these conditions in practice the better.

Where public roads are altered in level, a cross section is required to be deposited, shewing the nature of the alteration. The level of any turnpike road must not be altered to a steeper rate of inclination than 1 in 30, or of any other public road to 1 in 20.

The height of the railway over or depth under the surface of any turnpike or public carriage road, navigable river, canal, or existing railway, must be marked in figures at each crossing thereof, as well as a memorandum made of the height and span of the bridge or arches by which the crossing is proposed to be effected.

If the railway passes any turnpike, or public carriage road, or railway, upon the same level, a memorandum to that effect must be made upon the section. The section must be miled to correspond with the plan, and a very full and explicit description of the datum line must be noted thereon. All tunnels and viaducts must be drawn upon the section, and the extreme height of every embankment, or depth of cutting, when the same exceeds 5 feet, must be marked. With the addition of the horizontal and vertical scale, the section is complete. Plates 8 and 9 represent a map and

* Generally speaking a practice fraught with great danger to the public, saving present outlay, at the cost of annual expenditure.

section, in accordance with the requirements of Standing Orders.

The Parliamentary deposits involving several copies, lithography is usually resorted to for the purpose of supplying them. This is a very sore point with most engineers and surveyors; few there are who cannot call to mind some case, many there are who have experienced several, nay, are yearly experiencing them, in which very excellent drawings have been entirely botched and placed below par in their passage, through the office of the lithographer in the last days of November. Some of the most anxious hours of my professional life have been spent in these offices, alternating between hope and fear, and speculating upon the probable chances of the work being completed in time for deposit. Lithographers rarely refuse works of this description, however many of them they may have in hand; so well are they acquainted with the absolute necessity of their completion by a certain time and the safe pretext it affords for making a very heavy charge. I dare say this is fair enough as a stroke of business policy, but I think they should say when they have as much in hand as they can creditably accomplish.

I do not assert that lithography and zincography are not admirably adapted for this very purpose of multiplying copies of plans and sections, if used as an art should be, and not abused; but speaking from ample experience in both methods, I advisedly say, that if time is short, and a sufficient number of assistants capable of making tracings can be secured, with a man to mount them, the deposit of mounted tracings will be found both economical and preferable. It is easy to calculate the number of tracings of any one or more sheets of drawing a clerk will make, in a given time, and it can be done under the surveyor's own superintendence; but he cannot know how long zincography will take to execute unless he knows how many other works of a similar nature the lithographer has in hand at the same time. The objection that in the case of tracings they may not be all alike, does not well apply if they are carefully made, and if they are mounted upon a preparation of white paper mounted on holland, and are neatly drawn, they look very nicely.

The deposits duly made, the engineer has a rest on the 1st December sweeter than can be realised by the non-experienced reader. The work of serving the notices devolves upon the solicitors and their local agents; but the engineer must furnish the information for the notices, as to what properties are situated on the line as laid out, and what are only within the limit of deviation; with the nature of the works proposed to be constructed on such properties.

The plans, sections, and book of reference being once deposited

become public documents to which any one may have access at the Private Bill Office on payment of five shillings for an inspection or one pound for the privilege of copying them. At the office of the Clerk of the Peace of the County, the Documents may be inspected for one shilling, or copied at a charge of one shilling an hour for every hour during which a person is so engaged. This publicity of the Deposited Documents, is further coupled with the privilege to every person who may be specially affected by the non-compliance with any standing order to appear, and to be heard by themselves, their agents, and witnesses upon a memorial addressed to the examiner complaining of such non-compliance, provided the matter complained of be specifically stated in such memorial, and the party so specially affected has signed the same and shall not have withdrawn his signature thereto, and such memorial has been duly deposited in the Private Bill Office. The memorial complaining of the non-compliance with the standing orders, if the same relate to the petition for a Bill numbered in the General List of Petitions:—

From	1 to 100	must be deposited on or before	January 17
„	101 to 200		„ 24
„	201 upwards		„ 31

before six o'clock in the evening of any day in which the house shall sit, and before two o'clock on any day on which the house shall not sit; and two copies of such memorial for the use of the examiners must be deposited before twelve o'clock on the following day.

The object of the Legislature in framing the standing orders, and in granting these privileges was manifestly a very sound and just one; affording, as they were evidently intended to do, the means by which every landowner and occupier could ascertain the exact extent and manner by which his particular interests would be affected; at the same time giving him the legitimate means of opposing the passage of the Bill through the House if he should be hostile to its preamble, or dissatisfied with its provisions or clauses.

The examination of the petitions for private Bills which have been duly deposited in the Private Bill Office, commences on the 25th day of January, in such order, and in accordance with such regulations as shall be made by the Speaker.

Seven days' notice is given by the Examiner in the Private Bill Office, of the day appointed for the examination of each petition and in case the promoters do not appear at the time appointed, the examiner strikes the petition out of the list, and has no power to re-insert it without the order of the House.

The examiner endorses upon the petition, a certificate of compliance or non-compliance with the standing orders, and in the event of the latter, he reports to the House the facts upon which his decision is founded.

A description of the several stages by which a Railway Bill passes through Parliament, is hardly in accordance with the intentions of this paper; those who wish to acquaint themselves fully upon the subject, can do so by reference to a "Treatise upon Parliamentary Proceedings," lately published by Mr. May, one of the Examiners.

Sec. 2.—Proceedings subsequent to the passing of the act.

The first operation after the passing of an Act of Parliament authorising the formation of a railway is the carrying out a very careful and particular survey and the preparation of an exceedingly accurate map, plotted to a scale of two chains to an inch, or some other large scale exhibiting faithfully every possible detail. Upon this plan all the future works can be correctly laid down, and the contents of the several lands required can be accurately computed. When these plans are completed the line of railway is carefully laid down thereon, either in the same course as drawn on the deposited plans, or in such an altered direction within the limits of deviation, as subsequent enquiries and a less hurried examination may have suggested.

Now comes the important business of setting out the centre line. To do this with accuracy is frequently a troublesome operation, depending upon the nature of the ground. For, with the most accurate plan, it is not always possible at the first attempt in a hilly or a wooded country to range the long straight pieces of the line; if a piece of rising ground can be found intermediate, from which both ends can be seen, or any other two well defined points upon the plan which can be exactly identified upon the land, the best course to adopt will be to plant a theodolite or transit instrument upon the high ground with which the line can be ranged towards either end. Practice and experience are required to set out these straight lines with accuracy. A person accustomed to the conduct of large surveys will do this work much more readily than the constructive engineer. It is always advisable, however long the staight lines may be, to commence the ranging in the centre, and for this reason; a very small deviation at the commencement, although too minute to be detected on the Plan, would become clearly discernible, and require correction if carried on and increased throughout

the whole line; but if the work commences in the centre this error can at any rate only arrive at half the magnitude, and may possibly to that extent be unimportant.

It is desirable, if possible, that the straight lines forming tangents to curves, should be produced until they intersect each other, where a flag staff should be erected as a permanent mark of reference throughout the construction of the works. This cannot often be done, but the tangents should at all times be produced to some spot beyond the works, whereon the pole may be erected, so that its continuance may not interfere with or be likely to be disturbed by the convenience of the landowners and occupiers.

The methods of setting out curves, to which I purpose to direct attention here, are five in number. The three first are given by Mr. Law, in Simms' Treatise on Levelling, the fourth is described by Mr. Rankin, in a communication to the Institution of Civil Engineers, and the fifth is a method suggested by myself, in a Book of Tables, (published about five years since,) for setting out slopes and curves. Mr. Law's first method is that which has in practice, perhaps, been most extensively used, although it possesses some objections which I shall point out in the sequel.

Let A B and C D, (fig. 1, plate 6) be the two straight portions of the line, which it is desired to connect by a curve; B and C being the two points at which the curve falls into the straight lines; and let B b_1, b_1 b_2, b_2 b_3, &c., be the distance which it is desired that the points to be found in the curve shall be apart. Then measure upon the straight line A B produced, the distance B a_1, equal δ_1, in formula IV below, and from the point a_1, set off, perpendicular to the same line, the distance a_1, b_1, equal to o_1, in formula III, which will give the first point required in the curve; then range a straight line through the points B, b_1, and upon this line lay off the distance b_1, a_2, equal to δ_2, in formula VI, and from the point a set off perpendicular to the line B a_2, the distance a_2, b_2, equal to o_2 in formula V, and the point b_2 will be the second point in the curve; then in a similar manner range another line through the points b_1 b_2, upon which measure the distance b_2 a_3 equal to the distance δ_2 or b_1 a_2, and from a_3 set off as before, perpendicular to the line b_1 a_3, the distance a_3 b_3 equal to o_2, which will determine the third point in the curve; and thus proceed until the whole extent of the curve has been set out.

In order to obtain the values of δ_1, δ_2, o_1 and o_2, let r equal the radius and d equal the distance B b_1, or b_1 b_2, &c., which it is desired that the points found in the curve shall be apart, (both expressed in feet); then

$$\frac{d^2}{2\,r} = o_1 \quad \text{III.}$$

$$\sqrt{d^2 - o^2} = \delta_1 \quad \text{IV.}$$

$$\frac{d\,\delta_1}{r} = o_2 \quad \text{V.}$$

$$\frac{d\,(r - o_1)}{r} = \delta_2 \quad \text{VI.}$$

As an example of the application of this method, let the radius of the curve (r) be 15 chains or 990 feet, and the distance B b_1 (d) one chain or 66 feet; then from formula III

$$\frac{66^2}{2 \times 990} = 2{\cdot}2 \text{ feet} = o_1$$

will be the first offset at a_1; and

$$\sqrt{66^2 - 2{\cdot}2^2} = 65{\cdot}963 \text{ feet} = \delta_1$$

will be the distance B a_1, to be laid off upon the line A B produced to give the place for this offset. Again,

$$\frac{66 \times 65{\cdot}963}{990} = 4{\cdot}397 \text{ feet} = o_2$$

will be the offset at a_2, a_3, a_4, &c.; and

$$\frac{66 \times (990 - 2.2)}{990} = 65{\cdot}85 \text{ feet} = \delta_2$$

will be the distance b_1, a_2, b_2 a_3, &c., to be measured from the points b_1, b_2, &c., in order to give the points a_2, a_3, a_4, &c., from which the offsets o_2 are to be taken.

To this method there are, as has been already stated, some practical objections, inasmuch as any error which may be committed in setting out only one of the points in the curve, will occasion a corresponding error in every succeeding one; and a very trifling inaccuracy in calculating either the distance δ_2, or the length of the offset o_2, from its being frequently repeated, may ultimately cause a very considerable deviation from the true curve. Both these objections, however, may be in a great measure removed by the adoption of the following method of checking the position of about every fifth point; or which would be better, first determining the position of these points, and then filling in the intermediate ones; and as I consider this modification does away almost entirely with the above mentioned sources of error, I shall give an example of its application.

Suppose r and d, or the radius, and the distance the points B, b_1, b_2 &c., are apart (see fig. 2, plate 6) to be the same as in the last example, viz., 990 feet and 66 feet respectively, and let it be determined to check the position of every *fourth* point: then the

values of δ_1, δ_2, o_1 and o_2, will be the same as before; but previous to setting out points b_1, b_2, b_3, &c., we must calculate the distance B B_1, to be measured along the line A B produced, and the distance B_1, b_4, to be set off from the point B_1 to give the position of the fourth point (b_4) in the curve: which may be done as follows: Let the distance B B_1 equal $\triangle_1$ and B_1 b_4 equal O_1; and let D_1 be the length of the chord line connecting the two points B and b_4, and β be the angle a_1 B b_1; then

$$\frac{o_1 \text{ rad}}{d} = \sin \beta,$$

and

$$\frac{2\,r \sin 4\,\beta}{\text{rad}} = D_1.$$

Then, by substituting D_1, O_1, and $\triangle_1$ for d, o_1, and δ_1 in the formulæ III, IV, V, and VI, we shall obtain the values of O_1, $\triangleright_1$, O_2 and $\triangleright_2$, where $\triangleright_2$ is the distance b_4 B_2 to be measured upon the chord line B_1 b_4 produced, and O_2 is the distance B_2 b_8 to be set off from B_2 in order to give the eighth point (b_8) in the curve; for the values of r and d given above we shall obtain

Log of o_1	= 0·342423	= 2·2
Log rad	= 10·000000	
	10·342423	
Log of d	= 1·819544	= 66
Log sin of β	= 8·522879	

and $\beta = 1°\ 54'\ 37''$; then

Log of 2 r	= 3·296665	= 1980
Log sin of 4 β	= 9·123745	= 7° 38′ 28″
	12·420410	
Log rad	= 10·000000	
Log of D_1	= 2·420410	= 263·27.

Then from formula III,

$$\frac{263{\cdot}27^2}{2 \times 990} = 35 \text{ feet} = O_1;$$

from formula IV,

$$\sqrt{263{\cdot}27^2 - 35^2} = 260{\cdot}92 \text{ feet} = \triangleright_1;$$

from formula V,

$$\frac{263{\cdot}27 \times 260{\cdot}92}{990} = 69{\cdot}4 = O_2;$$

and from formula VI,

$$\frac{263{\cdot}27 \times (990 - 35)}{990} = 253{\cdot}96 = \triangleright_2.$$

These being obtained, the position of every fourth point, b_4, b_8, b_{12}, &c., should be first determined by the dimensions Δ_1, O_1, Δ_2, and O_2; and then the intermediate points, b_1, b_2, b_3, b_5, b_6, &c., by δ_1, o_1, δ_2, and o_2, as first described.

The second method which I shall describe may be advantageously employed when the radius of curvature is large and the centre can be seen from every part of the curve.

Let the lines (fig. 3, plate 6) A B and C D, as before, represent the two straight portions of the line required to be connected by a curve having a radius of 80 chains or 1 mile. First, set up a theodolite at B and another at C (the two terminations of the straight portions of the line) and from each point range a line at right angles to the lines A B and C D respectively, and at the intersection of these lines (E) which will be the centre of the curve, put up a signal sufficiently conspicuous to be seen from any point between B and C: then produce the straight lines A B and C D until they intersect in the point F, and on these lines drive in stakes at equal distances, a_1, a_2, a_3, &c., commencing from the points B and C. If r equal the radius, and δ equal the distance between the points a_1, a_2, a_3, &c., both in feet, then

$$\sqrt{r^2 + \delta^2} - r = o_1,$$

will be the distance which must be set off from the first point a_1, not perpendicular to the line B F, but in the direction a_1 E; in like manner

$$\sqrt{r^2 + \overline{2\ \delta}|^2} - r = o_2,$$

will be the distance to be set off from the point a_2 in the direction a_2 E; and generally

$$\sqrt{r^2 + \overline{n\ \delta}|^2} - r = o_n,$$

will be the distance to be set off at the nth points from B and C.

For example, let r be 5280 feet and δ equal 100 feet; then

$$\sqrt{5280^2 + 100^2} - 5280 = \cdot 94 \text{ feet} = o_1$$

will be the distance $a_1\ b_1$, which must be set off from a_1 in the direction a_1 E to obtain the first point b_1 in the curve, and proceeding in a similar manner with the others, the following table will exhibit the distances to be set off at the respective points a_1, a_2, a_3, &c.

At a_1	or 100	feet	from B, the offset will be	·94 feet
a_2	200	,,	,,	3·79
a_3	300	,,	,,	8·52
a_4	400	,,	,,	15·13
a_5	500	,,	,,	23·62
a_6	600	,,	,,	33·98

At	a_7	or 700 feet	from B, the offset will be	46·19
	a_8	800	„ „	60·26
	a_9	900	„ „	76·16
	a_{10}	1000	„ „	93·86
	a_{11}	1100	„ „	113·36
	a_{12}	1200	„ „	134·65
	a_{13}	1300	„ „	157·68
	a_{14}	1400	„ „	182·45
	a_{15}	1500	„ „	208·93

If the extent of the curve is such that the length of the offsets before reaching the point F where the two tangent lines intersect become inconveniently long, so as to occasion a loss of time in setting them off, it will be advisable to make use of another tangent line as shewn at G I, fig. 4, plate 7; for determining the position of which line the following method may be made use of. Let r, as before, be the radius, ϵ the number of degrees contained by the angle B E C, and n the number of tangent lines (as B G, G H, H I, I C) intended to be employed; then

$$\frac{r \sin \frac{\epsilon}{n}}{\cos \frac{\epsilon}{n}}$$

will equal the length of any one of these tangent lines. As an example, let r equal 5280 feet, ϵ equal 60°, and n equal 4; then

Log of r = 3·722634 = 5280

Log sin $\frac{\epsilon}{n}$ = 9.412996 = 15°

13·135630

Log cos $\frac{\epsilon}{n}$ = 9·984944

3·150686 = 1414·8 feet

will be the length of the lines B G, G H, &c.

Now having ascertained this length, nothing more remains than to set it off from B and C towards F, and then to range a line G I from the two points thus obtained, which will be the required tangent line: this line must then be bisected in the point H, which may readily be done by ranging a line from F to E, which having been done, proceed as already described to set off the equal distances a_1, a_2, a_3, &c. from B and H towards G, and from H and C towards I; and then by setting off the distances $a_1 b_1$, $a_2 b_2$, &c. contained in the Table already given, from the several points

a_1, a_2, &c., in directions radiating to the centre E, the course of the curve will be marked by the points b_1, b_2, b_3, &c. thus obtained.

One advantage possessed by the above method is, that knowing exactly the direction in which to lay off the offsets, (and that by the range of a comparatively distant object,) the errors which have frequently arisen from their not having been set off perpendicularly, where the eye has been the only criterion, are entirely obviated; and this method is also entirely free from the objections made to the former method.

When the centre point E cannot be seen from every part of the curve, so as to allow of the offsets been laid off radially, the more usual method may be adopted of laying off the offsets perpendicularly to the tangent B F, but in this case a cross staff should always be employed to insure accuracy, and the distances to be set off from the points a_1, a_2, a_3, &c. will be greater than those employed in the previous method, and must be calculated from the formula

$$r - \sqrt{r^2 - \delta^2} = o_1$$

instead of that given at page 355.

The third method is most applicable where the radius of the curve is small as compared with its extent, and is deduced from the well known theorem, that all angles contained in the same segment of a circle are equal to one another.* The method is as follows:—place a theodolite at B and another at C, (fig. 5, plate 7) the two terminations of the straight portions of the line, setting the telescope of the instrument at B on C, and that at C on F, the point of intersection of the lines A B and C D produced; then if the former be moved through an arc of any number of degrees, towards F, and the latter the same number of degrees towards B, the point a_1, where the lines of collimation of the two telescopes intersect, will be a point in the curve; now let both theodolites be again moved the same number of degrees and in the same directions as before, and their axes produced, or lines of collimation, will again intersect at a_2, another point in the curve; and in fact, to whatever extent the theodolites are moved, so long as the arc described is equal in both, the point of their intersection will always be in the required curve. Or more generally, suppose the two theodolites to be placed as first described, and then simultaneously to commence to revolve with the same uniform angular velocity, the point of intersection of their lines of collimation will describe the circular arc C, a_1, a_2, a_3, ... B; and in equal intervals of time, equal portions of the arc will be described, which will be half as great as the arc, which would have

* Euclid, Book III. prop. 21.

been described in the same time, by the same angular velocity, at the centre of the circle (E); from which last mentioned circumstance, we may readily calculate the magnitude of the angle through which the theodolites at B and C must be successively moved, in order that the points a_1, a_2, a_3, &c., at which their axes intersect, may be at the distance apart which it is desired that they should be. If r equal the radius of the curve, d the required distance, and β the angle a_1 B C; then

$$\frac{d \text{ rad}}{2\,r} = \sin \beta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{VII.}$$

As an example of the application of this method, let r equal 20 chains, or 1320 feet, and let it be required to determine points in the curve at distances of about 100 feet; now from the above formula we shall obtain

Log d	=	2·000000	=	100
Log rad	=	10·000000		
		12·000000		
Log 2 r	=	3·421604	=	2640
Log sin β	=	8·578396	=	2° 10′ 15″

As it would be inconvenient, however, in practice, to lay off so frequently as would be required an angle, with odd minutes and seconds, we may instead of the above take an angle of 2 degrees, which will make the distance d equal 92·13 feet. Having thus determined the angle, and placed the theodolites as previously described, viz., that at B in the direction of B C, and that at C in the direction C F; the former must be moved 2° towards F, and the latter 2° towards B, and a stake driven down at their point of intersection a_1, the former must then be removed 2° more towards F, and the latter 2° towards B, and another stake put down at their point of intersection a_2, and so on until the theodolite at B, is brought to the direction B F, and that at C to the direction C B, when the whole of the curve will have been staked out as required the stakes being 92·13 feet apart. This method, the same as the last is not liable to the objections that the first method was, and in addition possesses the very important practical advantage, that its accuracy is entirely independent of any undulation or change of level in the surface of the ground, an advantage which is not possessed by any of the other methods which I have described, the whole of which would require to have the distances and offsets corrected in proportion to the slope of the surface of the ground. In a hilly country—and it is in such districts that curves most frequently occur—this circumstance will render the last described method far superior to either of those which precede it.

The next method which I shall give, is that described by Mr. Rankin, in a communication to the Institution of Civil Engineers, and depends on the theorem* that the angle, subtended by any arc of a circle at the centre of the circle, is double the angle subtended by the same arc at any point in the circumference of the circle. The method of proceeding is as follows:—first place a theodolite at B (fig. 6, plate 7) the point where the curve commences; and then lay off from the line B F, the angle B, calculated from formula VII, (supposing, as before, r to represent the radius of the curve, and d the distance required between the points in the curve,) and in the direction of the axis of the instrument set off the distance d, which will give the first point a_1 in the curve; in the same manner lay off from B F the angle 2β, and from a_1 set off the same distance d, and the point where it cuts the axis of the instrument produced will be the second point a_2; and generally by laying off the angle $n\beta$, and setting off from the proceeding point a_m, the distance d, the point a_n will be given.

As an example of the application of this method, let r equal 19 chains, or 1254 feet, and d equal 100 feet; then from formula VII we obtain

Log d	=	2·000000	=	100
Log rad.	=	10·000000		
		12.000000		
Log $2r$	=	3·399328	=	2508
Log sin β	=	8·600672	=	2° 17′ 6″

then having placed the theodolite at the point B, lay off this angle 2° 17′ 6″ from the line B F, and upon the line B a_1 thus obtained set off 100 feet, which will give the first point in the curve a_1; then with an angle of 4° 34′ 12″ or 2β set off another 100 feet from a_1, which will give the second point a_2, and thus proceed, until the whole extent of the curve has been set out.

The last method I extract from my own Work upon the subject.

"Suppose we have arrived, by a piece of straight work, at the commencement of a curve, of 80 chains radius, which for demonstration we will call point A, (fig. 173*f*); the first proceeding is to produce the straight line or tangent, one chain to C; then turning to the tables (as hereafter explained) we find the single offset C D = 4.9 inches; this must be very exactly set off at *right angles* (in the first case only) with the tangent A C to D, which becomes a point in the curve. We now produce A D, one chain to E. Then turning again to the tables, we ascertain the double offset,

* Euclid, book III, prop. 20.

(as the single offset serves only to connect the tangent with the curve,) to be 9.9 inches; so with one handle of the chain held firmly at D, and one end of a tape held at E, we proceed to make D F = one chain; and E F = 9.9 inches; and F is another point in the curve. We then produce D F in the same manner as A D, and so on throughout to the end of the curve;—always bearing in mind that the tangent leaves the curve as it came on, with the single or half offset, as shewn at I.

The above method requires some further test to ensure complete accuracy, as explained with reference to the first method.

We will again suppose ourselves at the commencement of the curve, which we will now consider point A, fig. 173*g*; produce the straight line ten chains to C; there erect a perpendicular,* which, on reference to the tables, we find to be 62.7 links, and being accurately set off, we obtain D, a point in the curve.

In measuring the ten chains A C, reference is required to the tables to ascertain the point B at which the next tangent intersects, and which is found to be 502 links from A, at which point a mark should be set up.

If we produce a line formed by the points B and D, ten chains from D to F, we have a new tangent D F with which to proceed in the same manner as with A C: and so on throughout the continuance of the curve.

The dimensions A C and C D, D F and F G, &c., corresponding respectively with the sine and versed sine of the curve, and being of sufficient length to bear a comparison with the radius, must obviously subtend to great accuracy.

The tables afford one other test, by giving the angles C B D, F E G, &c., between the intersecting tangents, = in our illustration, 7° 10′ 50″

Example.

It is required to set out a curve of 20 chains radius:

Seek in the column headed "radius" in the tables, 20 chains, then opposite the radius in

Column 2, is the single offset C D, fig. 173*f*, = 1-ft. 7.8 inches.

Column 3, is the double offset E F, fig. 173*f*, = 3-ft. 3.6 inches.

Column 4, is the perpendicular C D, fig. 173*g*, at 10 chains on the tangent A C = 267.9 links.

Column 5, is the distance A B on the old tangent A C, at which the new tangent B F intersects = 536 links; and in

Column 6, is the angle C B D, fig. 173*g*, formed by the intersection of the old and new tangents = 30 deg.

* This perpendicular being of some length is calculated in the tables to links, as more easily measured with a chain than a tape.

TABLES FOR SETTING OUT CURVES.

RADIUS.	SINGLE OFFSET AT 1 CHAIN ON TANGENT.	DOUBLE OFFSET AT 1 CHAIN ON TANGENT.	PERPENDICULAR OFFSET AT 10 CHAINS ON TANGENT; OR CORRESPONDING VERSED SINE.	DISTANCE ON THE OLD TANGENT AT WHICH THE NEW ONE INTERSECTS.	ANGLE FORMED BY THE INTERSECTION OF THE OLD AND NEW TANGENTS.
Chains.	Feet. Inches.	Feet. Inches.	Links.	Links.	Deg. Min. Sec.
10	3 3.6	6 7.2	1000.	1000	90 0 0
11	3 0.	6 0.	641.7	706	65 22 34
12	2 9.	5 6.	536.6	644	56 26 33
13	2 6.4	5 0.9	469.3	610	50 17 5
14	2 4.2	4 8.5	420.2	588	45 35 4
15	2 2.4	4 4.8	381.9	573	41 48 37
16	2 0.7	4 1.5	351.	562	38 40 55
17	1 11.3	3 10.6	325.2	553	36 1 54
18	1 10.	3 8.	303.3	546	33 44 56
19	1 8.8	3 5.6	284.4	540	31 45 24
20	1 7.8	3 3.6	267.9	536	30 0 0
25	1 3.8	2 7.6	208.7	522	23 34 41
30	1 1.2	2 2.4	171.5	515	19 28 16
35	0 11.3	1 10.6	145.9	511	16 36 5
40	0 9.9	1 7.8	127.	508	14 28 39
45	0 8.8	1 5.6	112.5	506	12 50 22
50	0 7.9	1 3.8	101.	505	11 32 13
55	0 7.2	1 2.4	91.6	504	10 28 32
60	0 6.6	1 1.2	83.9	503	9 35 38
65	0 6.	1 0.1	77.3	503	8 50 58
70	0 5.6	0 11.3	71.8	502	8 12 47
75	0 5.2	0 10.5	66.9	502	7 39 44
80	0 4.9	0 9.9	62.7	502	7 10 50
Miles. Fur.					
1 1	0 4.4	0 8.8	55.7	502	6 22 45
1 2	0 3.9	0 7.9	50.1	501	5 44 21
1 3	0 3.6	0 7.2	45.5	501	5 12 57
1 4	0 3.3	0 6.6	41.7	501	4 46 48
1 5	0 3.	0 6.	38.8	500	4 24 42
1 6	0 2.8	0 5.6	35.7	500	4 5 45
1 7	0 2.6	0 5.2	33.3	500	3 49 21
2 0	0 2.4	0 4.9	31.2	500	3 35 0
2 2	0 2.2	0 4.4	27.8	500	3 11 5
2 4	0 1.9	0 3.9	25.	500	2 51 57
2 6	0 1.8	0 3.6	22.7	499	2 36 18
3 0	0 1.6	0 3.3	20.8	499	2 23 16

Having now given several methods by one or other of which all curves may be correctly set out, the object of my paper has been satisfied. I might have gone at some length into the absolute necessity for all curves to be truly tangential to the straight work, as well as to each other; the practical tests that are required when working from an incorrect map (although as a surveyor I am bound to say the map should, in all cases, and for many reasons, be a very good one,) but I have felt that I could not do so without going still further, and perfecting, what is not at all intended, a complete treatise on the subject. I venture to suggest that much future economy always depends upon the manner in which the curves of a railway are originally laid out; to say nothing of the jerks and unpleasant oscillations to which the passengers are subjected if they are untrue, or the danger by that means incurred.

As soon as the line is set out, a square peg, about two and a half inches in section, and two feet long, should be driven into the ground about twenty inches, at intervals of a chain, very carefully and correctly measured from one of the termini, and between each of these pegs a triangular sod, about ten inches wide, should be cut out, and this is what is called "nicking out."

I should observe, that at the tangent points of the curves a peg should be driven in, although they may not fall at an equal chain's length; and to secure the certainty of finding the exact point at a future occasion, a peg should be driven into some place where it may remain undisturbed, on either side of the line, directly at right angles with the tangent.

When the line is stumped and nicked out, we prepare for making the "Working Section," by driving into the ground by the side of each of the chain stumps a peg for the levelling staff to stand upon. These pegs should be about fifteen inches long and two and a half inches square, and should be driven into the ground level with the surface.

The levels are then minutely taken at each chain, or oftener if any variation in the ground between the chain pegs require it, and for the purposes of the method I am about to describe for setting out the slopes, a reading should be also obtained from the staff, held at fifty links from the centre peg on either side of the line. This extra reading furnishes the rate of inclination per chain of the cross section. What are called permanent posts, for B. Ms. of reference during the execution of the works, should be fixed at intervals, as the levelling proceeds in situations not likely to be disturbed. They may be about four feet in length, should be hooped at top to prevent them from splitting, and should have an iron plate

on the top of them for the staff to stand upon. To these B. Ms. the levels must be very accurately proved. Plate 11 is a specimen of a working section.

When the working section is completed, the gradients may be carefully laid on. Two lines will be required to be drawn upon the section: the upper one representing the top surface of rails when laid, and the lower one exactly two feet below the other one, the line which is called the "Formation Level," that is the line to which the cuttings and embankments have to be constructed.

Engineers generally insert upon their working sections two sets of figures—some shewing the height of the formation level at every chain above the datum line, and the depth of cutting or height of embankment; others shewing the heights of the level pegs above the datum line at the surface of the ground, and the depths of cuttings or height of embankments. In my opinion, the section should exhibit all three, viz., first, the height of the surface peg above the datum line; secondly, the height of the formation level above datum at every chain, arrived at by calculation; and, thirdly, the depth of cutting or height of embankment, arrived at by the subtraction of the first and second row of figures, the one from the other.

On Setting out the Widths of Ground required for the Works of a Railway or Canal, &c., &c.

I shall give two methods of setting out slopes. The first will be the same as given in *Simms' Levelling*. The second is extracted from Tables published by myself, under the title of the *Civil Engineers' and Surveyors' Assistant, in setting out Slopes, Curves, Cuttings, and Embankments.*

MR. SIMMS' METHOD.

When the natural surface of the ground, both longitudinally and transversely, is upon the same level as that of the intended works, the process of setting and staking out the widths is very simple. Let us take, for example, the case of a railway, the base or bottom width of which, when prepared for the reception of the ballasting and permanent way, is to be 36 feet; the ratio of the inclination, or batter, of the slopes to the heights, both in the cuttings and the embankments, to be 2 to 1; beyond which, or at the outward edge, a slip of land 12 feet wide is to be taken on each side of the railway for the fences, &c. First, the centre line must be staked out

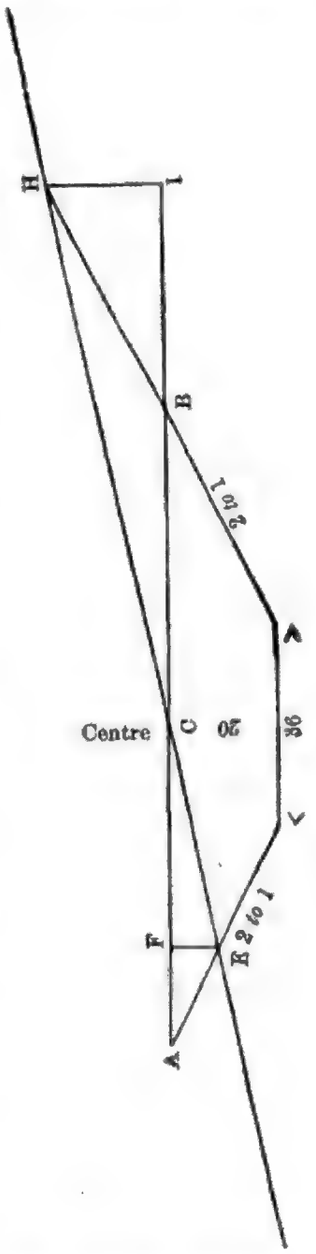
and carefully levelled: it is customary to drive a stake about 2 feet long, and about 1½ inches square, into the ground at each chain's length, their tops to be upon the fair level of the natural surface, thus affording good stations for the levelling staves to be held upon; the relative level of each stake being then very accurately determined with respect to some given datum, they become so many zero points for reference in the subsequent operations. From each of the centre stakes a line must be set out on both sides, and at right angles to the centre line, or at right angles to a tangent to the centre line at that point, if the centre line be curved; upon these transverse lines the required widths of land must be set out. Now, if the ground at any of the centre stakes is upon the same level as the intended base of the railway, nothing more will be required than to measure on each transverse line, and in both directions from the centre stake, one-half the required width, which, in our supposed case, is 18 feet for the half width of the railway, and 12 feet for the fences, in all 30 feet on each side of the centre. But when, as it mostly happens, the ground is not on the proposed level of the railway, the operation is not quite so simple; and if, in addition thereto, the ground slopes sidewise or at right angles to the general direction of the line, the business is still more complicated, and requires some skill and care to do the work correctly. The method of doing this is our business to explain.

The next most simple case to the above is when the cross section of the ground is horizontal, be the depth of cutting or height of embankment what it may.

This is shewn in fig. 173*h*, which represents a cross section of a 20 feet cutting with slopes of two horizontal to one perpendicular. The horizontal line at A B right angles to the centre line represents the natural surface of the ground. Under these circumstances it will readily be seen that the half width of the cutting, or the distance from the centre to the edge of the slopes C and D, equals the half width of the base (18) added to the batter of the sloping sides (40), and including the 12 feet for the fences, the total half width of land required for the purposes of such railway would be 18 + 40 + 12 = 70 feet, and consequently the whole required width to be so appropriated and fenced in for a 20 feet cutting or embankment, when the ground does not slope sidewise, would be 140 feet.

The next and more complicated, and also the most frequently occurring case, is, when the cross section of the natural surface is not horizontal, as shewn in the annexed diagram, which also represents a cutting of 20 feet.

Let the line A B represent a horizontal line, passing through the centre line C of the railway, which, if it coincided with the surface of the ground would give A C and C B (each half width) 70 feet, as in the former example, the depth of cutting and the slopes being assumed the same.



Let the line E H represent the natural surface of the ground upon this transverse section; it will readily be perceived that the real half width C E (on the left of the diagram) is much shorter than the horizontal or computed half width A C, because the ground-line is depressed on that side of the centre; likewise the half width C H on the other side of the centre is greater than the said horizontal or computed half width, because the ground is there elevated above the horizontal line A B passing through the centre. To determine *exactly* the distances C E and C H in actual operations in the field, would be attended with some difficulty, and consume much time; but the following method, which at the same time that it gives a sufficiently correct approximation in practice, is also a very expeditious one.

Let us suppose that the point E or distance C E be known, and that with a spirit level we determine the difference of level between the points C and E, this difference is represented by the line E F, which suppose to be one foot; now we have a small right angled triangle A E F, of which E F is determined, being the difference of level (one foot), and the slope or ratio of A F to E F also given, (2 to 1,) therefore the side A F is known (2 feet,) which subtracted from the computed half width A C, leaves F C approximately equal to E C, the required half width, sufficiently exact for all practical purposes, where the cross section of the ground does not differ materially from a horizontal line.

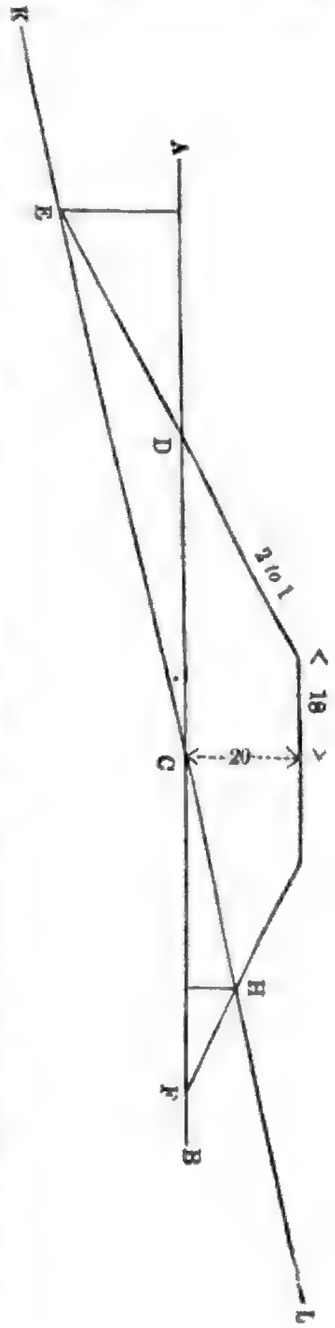
We have been supposing that the point E is known, whereas that point is the object of our search; in practice, therefore, we proceed thus:—take the computed half width, and if the ground is *depressed*, let a levelling staff be held somewhat *nearer* the point C

than the said computed half width, for a first approximation to the point E; then determine the *difference of level* between this assumed point and the centre point C, *multiply this difference of level by the ratio of the slopes,* (which doubles it when the slope is 2 to 1,) and *subtract* the result from the computed half width, which gives a more correct approximation to the point E; now hold the staff at this *new point* and find the difference of level as before; again multiply by the ratio of the slopes, and deduct the result from the computed half width, which second result will in most cases be sufficiently near the real half width for a *depressed* line for all practical purposes.

Example.—Central height (or depth of cutting), 20 feet, slopes 2 to 1, base 36 feet, the computed half width was therefore 58 feet; the ground being depressed, we estimated that the point E might fall short of the computed half width 2 feet; we therefore directed a levelling staff to be held at 56 feet from the centre line (or stake) C, at which point another staff was held, and by means of a spirit level set up at a convenient distance, we found the difference of level between these points to be 0·87 feet, which multiplied by the ratio of the slopes 2 to 1, gave 1·74 feet to be subtracted from the computed half width 58 feet, leaving 56·26 feet for a first approximation to the half width C E (see last diagram.) Now, upon removing the staff to this new point, the difference of level was again taken, (or rather we should say that the staff was again read off as the level had not been disturbed,) and found to be 0·91 feet, which also multiplied by the ratio of the slopes (2 to 1), gave 1·82 feet to be subtracted from 58 feet, leaving 56·18 for the second approximation, and which was adopted as the correct half width for the depressed side of the centre; indeed, in such a case as is above given, where the ground is so nearly horizontal, the first approximation (taken by a person after a little practice) may be assumed as the correct result, for in the above example it differed but ·08 from the second determination, and if it had been taken a third time, it could not have been more accurate as far as practice is concerned: this, however, is not the case where the inclination or slope of the ground is considerable, for then (if this method be followed) several approximations will be necessary to bring the result within admissible limits.

When the ground is *elevated* above the horizontal line, as shewn on the right hand of the diagram, the mode of procedure will somewhat differ: thus, instead of holding the staff and finding the difference of level at a *less distance* than the computed half width, it must be held at a *greater distance* to obtain the point H by approxi-

mation, the difference of level between that point and the centre point C being equal to H I, and multiplied by the ratio of the slopes will give the distance B I to be added to the computed half width C B, to obtain the half width C H; this may likewise be repeated to obtain a more correct result as described for the other, or depressed side of the centre C. It will also here be obvious to a person possessing but the smallest share of mathematical knowledge, that this result is not strictly correct, inasmuch as the line C H can never be equal to C I, but for practical purposes it is, as before observed, sufficiently correct. It may not be altogether unnecessary to observe, in this place, that the corrections B I, &c., as shewn in the foregoing diagrams, are much exaggerated, being far greater in proportion to the computed half width C B, than ever occurs in ordinary practice, but this has been done to make our explanations more distinct than otherwise.



The above particulars have been confined to the case of excavations; we must now shew in what the process differs when the ground is to be covered with an embankment.

By reversing fig. 173*h*, it then represents an embankment. The rule for finding the half width for an embankment where the transverse section of the ground is horizontal, remains the same as for the cuttings under like circumstances, as may be seen by an inspection of the inverted figure, but upon inverting the second diagram, it will at once be seen that some variation in the process is required. Thus:—

The horizontal line is represented by that marked A B; C D and C F the computed half widths; C E the required half width on the depressed side, and C H the required half width on the elevated side, the line K L representing the natural surface of the ground. In the case of an excavation, we have shewn that the *real* half width is greater on the *elevated* side than the computed half width, and less on the *depressed* side; but it will be seen by the diagram that for an embankment the *real* half widths are *less* on the

elevated side, and *greater* on the *depressed* side than the said computed half widths; therefore, in determining the approximate place of the point E on the depressed side for an embankment, the staff must be held *further* from the centre than the computed half width; and for the point H or the elevated side, it must be held *nearer* to the centre than the computed half width; and finally, for computing the real half widths from the differences of level between the points E and the centre, and H and the centre, on the *depressed* side the difference of level multiplied by the ratio of the slopes is to be *added* to the computed half widths to obtain the point E, and to be *subtracted* from the computed half widths to obtain the point H.

The process above described may appear to the reader a very tedious one; it perhaps is so to read, but a little practice will convince him that it is a very expeditious method, for in most cases one setting up of the level will answer for several stations, and the multiplications by the ratio of the slopes upon such small numbers as mostly occur is easily performed, especially if it be an even number as 2 to 1. The columns of the Field Book may be arranged as in the following example for making the calculations in the field, or may be abridged to suit a more convenient-sized book for the pocket, at the pleasure of the surveyor; indeed, all that can be accomplished now of this kind is to give general rules which can be altered and arranged to suit the convenience of the surveyor, as experience may point out a more suitable mode of proceeding. The example is taken from an extensive field operation by the writer, and shews the work both for a cutting and an embankment; the change from one to the other, or the tailing out of the cutting, as it is called, being included therein. The slope of the cutting is calculated at $1\frac{1}{2}$ to 1, and that of the embankment at 2 to 1. The width of the railway was 36 feet, consequently half the said width was 18 feet.

EXAMPLE.

No. of Stake.	Depth of Cutting or Embankment.	Computed half width.	Section or Level Readings at right angles to Line.			Difference of Level. + −		Difference of Level, × ratio of Slope. + −		Required half width for edge of Cutting or foot of Embankment.	
			South.	Centre.	North.	South.	North.	South.	North.	South.	North.
EMBANKMENT.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
285	16·97	51·94	10·90	7·50	3·96	+ 3·40	— 3·54	+ 6·80	— 7·08	58·74	44·86
286	1·43	20·86	7·06	4·74	3·24	+ 2·32	{+ 0·07 / − 1·80}	+ 4·64	+ 0·11	25·50	20·97
287	2·77	23·54	8·00	5·80	4·26	+ 2·20	— 1·54	+ 4·40	— 3·08	27·94	20·46
288	3·06	24·12	8·82	6·42	5·12	+ 2·40	— 1·30	+ 4·80	— 2·60	28·92	21·52
289	2·01	22·02	7·02	5·13	3·74	+ 1·89	— 1·39	+ 3·78	— 2·78	25·80	19·24
290	1·22	20·44	6·00	4·10	2·76	+ 1·90	{+ 0·12 / − 1·34}	+ 3·80	+ 0·18	24·24	20·62
291	1·91	21·82	7·52	6·95	5·20	+ 0·57	— 1·75	+ 1·14	— 3·50	22·96	18·32
CUTTING.											
292	1·39	20·78	12·20	11·35	10·52	— 0·85	+ 0·83	— 1·27	+ 1·24	19·51	22·02
293	4·51	27·02	9·56	7·98	6·22	— 1·58	+ 1·76	— 2·37	+ 2·64	24·65	29·66
294	5·72	29·44	8·40	6·52	4·27	— 1·88	+ 2·25	— 2·82	+ 3·37	26·62	32·81
295	6·85	31·70	7·06	5·10	3·02	— 1·96	+ 2·08	— 2·94	+ 3·12	28·76	34·82
296	8·61	35·22	7·53	5·28	2·76	— 2·25	+ 2·52	— 3·37	+ 3·78	31·85	39·00

The first column contains the number of the central stakes reckoned from the commencement of the work, which are convenient for reference.

The second column contains the depth of cutting or the height of embankment, as the case may be, at that point on the centre line.

The third column, the computed half width from the centre line to the edge of the cutting, or foot of embankment, upon the supposition that the ground is horizontal at right angles to the centre

line, this half width, as before explained, is found by multiplying the central height by the ratio of the slopes, and adding to the product half the width at the base of the railway.

The fourth, fifth, and sixth columns contain the readings from the levelling staves at the centre stake, and at the approximate points E and H, (see last diagram.)

The seventh and eighth columns contain the differences of level between the centre stake and the above approximate points. These numbers are simply the differences of the quantities in the three preceding columns, (except at stakes 286 and 290, which we shall presently explain,) and the signs + or — denote whether they are positive or negative quantities as respects the centre, and the approximate points E and H.

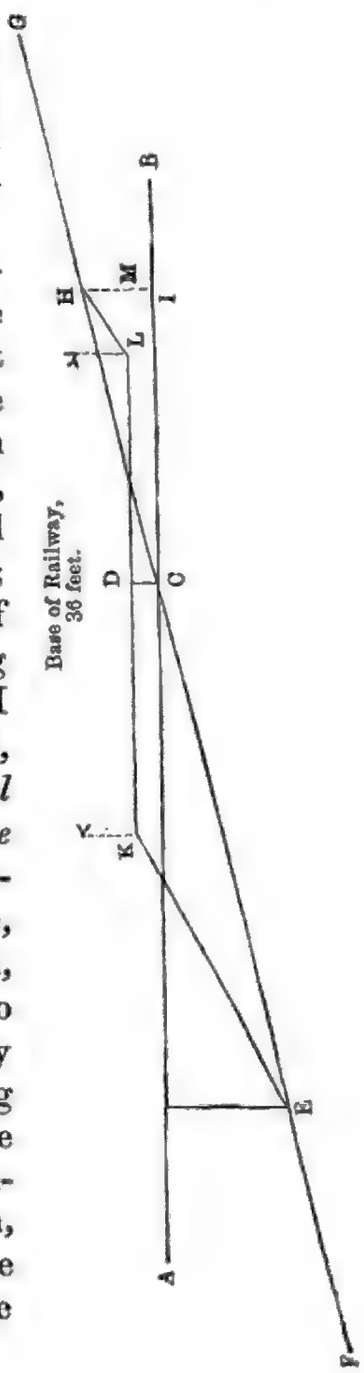
The ninth and tenth columns contain the differences of level (contained in columns 7 and 8) multiplied by the ratio of the slopes, and must have the same signs + or — as the corresponding numbers in the preceding columns.

The last two columns contain the final half widths, obtained by adding or subtracting, according to the prefixed signs + or —, the numbers in the two preceding columns to the computed half width contained in column 3.

After the explanations already given, the reader can find no difficulty in tracing the steps of the example, except perhaps with the stakes 286 and 290, where the difference of level on the north side is represented by two numbers bracketed together, one having the sign + and the other —: for the stake 286 the real difference of level on the north side the centre is a rise of 1·50, that is, the approximate point H is 1·50 feet above the centre stake: but it happens that the height of the embankment itself at that point is to be but 1·43 feet (column 2); therefore the approximate point H is above the intended top of the embankment, and consequently will not represent the foot of an embankment, but the edge of a cutting, and therefore the calculation for the half width on the north side, must be treated as for a cutting whose depth is equal to the *height of the approximate point* H *above the intended top of the embankment* or in other words, the *excess* of the difference of level between the centre stake and the approximate point H, above the intended height of the embankment, is the quantity to be entered in the column (7 or 8) "difference of level," and to be computed as for a cutting instead of embankment. In the case of stake 286 this excess is 0·07, to which is prefixed the sign plus; this sum multiplied by the ratio of the slope being additive (for a cutting) on the elevated side of the centre, as before explained.

For the stake 290, the north side of the line (column 6) is 1·34 higher than the centre stake, and it being embankment, would have the sign — prefixed (as shewn by the lower number, column 8): but the central height of the embankment at that point is but 1·22 (column 2); therefore, 1·34 — 1·22 = 0·12, which is the depth of cutting on the elevated side, and when multiplied by the ratio of the slopes, is to be added to the computed half width to obtain the correct result. When the surface of the ground is much inclined at right angles to the centre line, the numbers to be operated upon become proportionally large.

As it is a case of frequent occurrence that one side will be a cutting when the other is an embankment, we wish it to be well understood, and therefore annex the following diagram to illustrate it.



The line F G represents the natural surface of the ground, A B the horizontal line at the centre stake, C D the intended height of the embankment, K L the width or base of the railway, 36 feet, part of which is an embankment and part in cutting; the point E, or foot of the embankment will be determined in the usual way, as explained at page 368; but the point H, which is to be the edge of the cutting, must be found by subtracting D C (the height of embankment) from H I (the difference of level,) the remainder H M, (which is *the excess of the difference of level between the centre stake and the approximate point* H *above the intended height of embankment,*) multiplied into the ratio of the slope, must be added to the computed half width, or in other words, treated as for a cutting, to obtain the said point H as before stated. By reversing the diagram, the corresponding case will become evident, namely, when the centre line is in cutting, and one side on embankment, while the other is in excavation, and the mode of proceeding will at once strike the reader after perusing what we have above written.

MR. RYDE'S METHOD.

It will be observed, that the preceding method is somewhat complex and tedious, unless to the practised surveyor. In consequence of this, some few years ago, I turned my attention to the computation of a series of Tables which should obviate this and combine other advantages.

The first information required under my system is, the rate of inclination per chain of the cross section. This has already been directed to be taken while levelling for the working section, when it will be found to occupy but very little time. The whole work is then done in the office, with the exception only of measuring out the widths, which can be done by a surveyor of very limited experience.

I append Examples of the Tables, and of their use in Setting out Slopes, as well as a Specimen of the Field Book suited to them. It is hardly necessary to say that columns one, two, three, four, five, and six, are taken from the working section; that seven is computed; and that eight and nine are the tabulated results. And as these tabulated widths are given in links, they are more readily set out on the ground with a chain; they are easily set off on the plan by the scale with which the plan has been plotted; and the quantity of land required for the railway is simply and correctly computed. On the contrary, the system in general use gives the width of the railway only on the ground, from which it has to be measured before it can be laid off on the plan.

Explanation of the Tables for Setting out Slopes.

Note.—In these Tables fractional parts of feet are not given in treating of the depth of cuttings or height of embankments; it is considered sufficiently accurate in practice, when those decimals do not amount to half, to reject them altogether; when they do, to add one to the integer.

The columns of widths in links have been prepared by the same rule; and it may be well to observe, that these distances refer to horizontal measure.

If any case should occur exceeding the greatest depth of cutting or height of embankment given in the Tables, it is easily obviated by taking the half, and doubling the result.

The Tables have all been calculated by the application of logarithms to trigonometry, and are consequently of the most accurate solutions.

Examples.

Case 1.—When the surface of the land across the railway is level, and the work is a cutting or embankment.

Let fig. 173*b* represent the cross section of a railway in a cutting; the depth A B at the centre peg A being 40 feet, the width of the permanent way D G 30 feet, and the ratio of the base to the slope $1\frac{1}{2}$ to 1; required the widths A E and A F on either side the centre peg A?

First, find the distance B C by comparing the ratio of the slope with the half width of the permanent way B G or B D.

As $1\frac{1}{2}$: 1 :: B G 15 ft. : B C = 10 ft.

and B C being added to A B, we have a total depth of 50 feet to the point at which the slopes would intersect themselves and the vertical line A C, and form the triangles A C E and A C F.

A C = 50 feet depth of cutting becomes the reference to the Tables, under which, and the slope of $1\frac{1}{2}$ to 1, and opposite *level*, we have 114 links on either side—the widths required.

Case 2.—When the surface of the ground across the railway is not level, and the work a cutting or embankment:

Let fig. 173*c* represent the cross section of a railway in a cutting; the depth A B being 40 feet, the width of way D G 28 feet, the ratio of the base to the slope 2 to 1, and the rise per chain in the cross section E A F 4·5 feet; required the widths A E and A F on either side the centre peg A?

Proceed as in the last case to find B C

As 2 : 1 :: B G 14 ft. : B C = 7 ft.

A B = 40 + B C = 7 = A C 47 feet.

In the page of the Tables headed Depth of Cutting 47 feet, under slope 2 to 1, and opposite the rise of 4·5 feet per chain, stands the required widths, 165 and 125 links respectively.

Case 3.—When the surface of the land across the railway is not level, but when the centre of the railway is neither cutting nor embankment:

Let fig. 173*d* represent the cross section of a railway in which the width of way D G is 30 feet; the ratio of the slope 1 to 1; and the rise per chain in the cross section E A F 5 feet; required the widths A E and A F on either side the centre peg A?

Find A C = A B as before.

As 1 : 1 :: A D or A G = 15 feet : A C or A B = 15 feet.

In the page of the Tables headed Depth of Cutting or Height of Embankment 15 feet, under slope 1 to 1, and opposite rise per chain 5 feet, is 24 links; the greater width, which is here required on both sides, being the lower side of an embankment, and the higher of a cutting.

Case 4.—When the surface across the railway is not of one uniform inclination on either side the centre peg:

Let fig. 173*e* represent the cross section of a railway embankment, the height A B being 20 feet; D G 30 feet; ratio of the base to the slope 1½ to 1; and the rise per chain in the cross section E A 4.5 feet; and A F 7 feet; required the widths A E and A F on either side the centre peg A?

Find B C as before.

As 1½ : 1 :: B G 15 feet : B C 10 feet.

A B 20 plus B C 10 = A C 30 feet.

In the page of the Tables representing Height of Embankment 30 *feet*, under slope, 1½ to 1, and opposite a rise of 4.5 per chain, we have the lesser width A E 62 links, and farther down, opposite a rise of 7 feet per chain, we have the greater side A F 81 links.

SPECIMEN OF FIELD BOOK FOR SETTING OUT SLOPES.

DISTANCE ON RAILWAY.			NATURE OF WORKS.	DEPTH OF CUTTING OR HEIGHT OF EMBANKMENT.	WIDTH OF WAY.	RATIO OF SLOPES.	RISE PER CHAIN IN CROSS SECTION.	COMPUTED DEPTH OR HEIGHT FOR REFERENCE TO TABLES.	WIDTHS TAKEN FROM THE TABLES.		REMARKS.
Miles.	Fur.	Ch.		Feet.	Feet.		Feet.	Feet.	Links.	Links.	
11	2	5	Cutting	40	30	1½ to 1	Level	50	114	114	See case 1.
15	1	8	Cutting	40	28	2 to 1	4.5	47	165	125	See case 2.
19	0	6	Level	0	30	1 to 1	5.	15	24	24	See case 3.
19	7	4	Embankment . . .	20	30	1½ to 1	North 4.5 South 7.	30	62 —	— 81	See case 4.

SPECIMEN OF

TABLES FOR SETTING OUT SLOPES.

DEPTH OF CUTTING OR HEIGHT OF EMBANKMENT.

15 Feet.

Slope 1 to 1.			Slope 1½ to 1.			Slope 2 to 1.		
RISE per Chain in Feet.	Required Widths, in Links.		RISE per Chain in Feet.	Required Widths, in Links.		RISE per Chain in Feet.	Required Widths, in Links.	
Level	23	23	Level	34	34	Level.	45	45
.5	23	22	.5	34	34	.5	46	45
1.	23	22	1.	35	33	1.	47	44
1.5	23	22	1.5	35	33	1.5	47	43
2.	23	22	2.	35	32	2.	48	43
2.5	23	22	2.5	36	32	2.5	49	42
3.	24	22	3.	36	32	3.	50	42
3.5	24	21	3.5	37	31	3.5	51	41
4.	24	21	4.	37	31	4.	52	40
4.5	24	21	4.5	38	31	4.5	52	40
5.	24	21	5.	38	30	5.	53	39
5.5	25	21	5.5	39	30	5.5	54	39
6.	25	21	6.	39	30	6.	55	38
6.5	25	20	6.5	40	29	6.5	56	38
7.	25	20	7.	40	29	7.	57	37
7.5	26	20	7.5	41	29	7.5	58	37
8.5	26	20	8.	41	29	8.	60	36
8.5	26	20	8.5	42	28	8.5	61	36
9.	26	20	9.	42	28	9.	62	35
9.5	26	20	9.5	43	28	9.5	64	35
10.	27	20	10.	44	28	10.	65	35
10.5	27	19	10.5	44	27	10.5	66	34
11.	27	19	11.	45	27	11.	68	34
11.5	27	19	11.5	46	27	11.5	70	34
12.	28	19	12.	47	27	12.	71	33
12.5	28	19	12.5	47	26	12.5	73	33
13.	28	19	13.	48	26	13.	75	32
13.5	28	19	13.5	49	26	13.5	77	32
14.	29	19	14.	50	26	14.	79	32
14.5	29	19	14.5	51	25	14.5	81	31
15.	29	18	15.	51	25	15.	83	31

SPECIMEN OF

TABLES FOR SETTING OUT SLOPES.

DEPTH OF CUTTING OR HEIGHT OF EMBANKMENT.

30 Feet.

Slope 1 to 1.			Slope 1½ to 1.			Slope 2 to 1.		
RISE per Chain in Feet.	Required Widths, in Links.		RISE per Chain, in Feet.	Required Widths, in Links.		RISE per Chain in Feet.	Required Widths, in Links.	
Level	45	45	Level	68	68	Level	91	91
.5	46	45	.5	69	67	.5	92	89
1.	46	45	1.	69	66	1.	94	88
1.5	46	44	1.5	70	66	1.5	95	87
2.	47	44	2.	71	65	2.	97	85
2.5	47	44	2.5	72	64	2.5	98	84
3.	47	43	3.	73	64	3.	100	83
3.5	48	43	3.5	74	63	3.5	102	82
4.	48	43	4.	75	62	4.	103	81
4.5	49	42	4.5	76	62	4.5	105	80
5.	49	42	5.	77	61	5.	107	79
5.5	49	42	5.5	77	60	5.5	109	78
6.	50	42	6.	79	60	6.	111	77
6.5	50	41	6.5	80	59	6.5	113	76
7.	51	41	7.	81	59	7.	115	75
7.5	51	41	7.5	82	58	7.5	117	74
8.	52	40	8.	83	57	8.	120	73
8.5	52	40	8.5	84	57	8.5	122	72
9.	52	40	9.	85	56	9.	125	71
9.5	53	40	9.5	87	56	9.5	127	70
10.	53	39	10.	88	55	10.	130	70
10.5	54	39	10.5	89	55	10.5	133	69
11.	54	39	11.	90	54	11.	136	68
11.5	55	39	11.5	92	54	11.5	139	67
12.	55	38	12.	93	53	12.	143	67
12.5	56	38	12.5	95	53	12.5	146	66
13.	56	38	13.	96	52	13.	150	65
13.5	57	38	13.5	98	52	13.5	154	64
14.	57	37	14.	99	52	14.	158	64
14.5	58	37	14.5	101	51	14.5	162	63
15.	59	37	15.	103	51	15.	166	62

SPECIMEN OF

TABLES FOR SETTING OUT SLOPES.

DEPTH OF CUTTING OR HEIGHT OF EMBANKMENT.

47 Feet.

Slope 1 to 1.			Slope 1½ to 1.			Slope 2 to 1.		
RISE per Chain in Feet.	Required Widths, in Links.		RISE per Chain, in Feet.	Required Widths, in Links.		RISE per Chain, in Feet.	Required Widths, in Links.	
Level	71	71	Level	107	107	Level	142	142
.5	72	70	.5	108	105	.5	145	140
1.	72	70	1.	109	104	1.	147	138
1.5	73	69	1.5	110	103	1.5	149	136
2.	73	69	2.	111	102	2.	151	134
2.5	74	68	2.5	113	101	2.5	154	132
3.	74	68	3.	114	100	3.	157	130
3.5	75	67	3.5	116	99	3.5	159	129
4.	76	67	4.	117	98	4.	162	127
4.5	76	66	4.5	119	97	4.5	165	125
5.	77	66	5.	120	96	5.	168	124
5.5	77	66	5.5	122	95	5.5	171	122
6.	78	65	6.	123	94	6.	174	120
6.5	79	65	6.5	125	93	6.5	177	119
7.	79	64	7.	127	92	7.	180	117
7.5	80	64	7.5	128	91	7.5	184	116
8.	81	63	8.	130	90	8.	188	114
8.5	82	63	8.5	132	89	8.5	192	113
9.	82	62	9.	134	88	9.	196	112
9.5	83	62	9.5	136	87	9.5	200	110
10.	84	62	10.	138	87	10.	204	109
10.5	84	61	10.5	140	86	10.5	209	108
11.	85	61	11.	142	85	11.	213	107
11.5	86	61	11.5	144	84	11.5	218	105
12.	87	60	12.	146	84	12.	223	104
12.5	88	60	12.5	149	83	12.5	229	103
13.	89	59	13.	151	82	13.	235	102
13.5	89	59	13.5	153	81	13.5	241	101
14.	90	59	14.	156	81	14.	247	100
14.5	91	58	14.5	159	80	14.5	254	99
15.	92	58	15.	161	79	15.	261	98

SPECIMEN OF
TABLES FOR SETTING OUT SLOPES.

DEPTH OF CUTTING OR HEIGHT OF EMBANKMENT.

50 Feet.

Slope 1 to 1.			Slope 1½ to 1.			Slope 2 to 1.		
RISE per Chain, in Feet.	Required Widths, in Links.		RISE per Chain, in Feet.	Required Widths, in Links.		RISE per Chain, in Feet.	Required Widths, in Links.	
Level	76	76	Level	114	114	Level	151	151
.5	76	75	5.	115	112	.5	154	149
1.	77	74	1.	116	111	1.	156	147
1.5	77	74	1.5	117	109	1.5	159	145
2.	78	73	2.	119	108	2.	161	143
2.5	79	73	2.5	120	107	2.5	164	141
3.	79	72	3.	121	106	3.	167	139
3.5	80	72	3.5	123	105	3.5	169	137
4.	81	71	4.	124	104	4.	172	135
4.5	81	71	4.5	126	103	4.5	175	133
5.	82	70	5.	128	102	5.	178	131
5.5	82	70	5.5	129	101	5.5	182	130
6.	83	69	6.	131	100	6.	185	128
6.5	84	69	6.5	133	99	6.5	189	126
7.	85	68	7.	135	98	7.	192	125
7.5	85	68	7.5	136	97	7.5	196	123
8.	86	67	8.	138	96	8.	200	122
8.5	87	67	8.5	140	95	8.5	204	120
9.	87	67	9.	142	94	9.	208	119
9.5	88	66	9.5	144	93	9.5	212	117
10.	89	66	10.	146	92	10.	217	116
10.5	90	65	10.5	149	91	10.5	222	115
11.	91	65	11.	151	91	11.	227	114
11.5	92	64	11.5	153	90	11.5	232	112
12.	92	64	12.	155	89	12.	238	111
12.5	94	64	12.5	158	88	12.5	244	110
13.	94	63	3.	161	87	13.	250	109
13.5	95	63	13.5	163	87	13.5	256	107
14.	96	62	14.	166	86	14.	263	106
14.5	97	62	14.5	169	85	14.5	270	105
15.	98	62	15.	172	84	15.	277	104

TABLES OF RELATIVE GRADIENTS AND CORRESPONDING ANGLE.

1 CHAIN.	75 LINKS.	50 LINKS.	25 LINKS.	ANGLE.
Feet.	Feet.	Feet.	Feet.	Deg. Min.
.5	.37	.25	.12	0 25
1.	.75	.5	.25	0 51
1.5	1.12	.75	.37	1 16
2.	1.5	1.	.5	1 42
2.5	1.87	1.25	.62	2 8
3.	2.25	1.5	.75	2 33
3.5	2.62	1.75	.87	2 59
4.	3.	2.	1.	3 24
4.5	3.37	2.25	1.12	3 50
5.	3.75	2.5	1.25	4 16
5.5	4.12	2.75	1.37	4 41
6.	4.5	3.	1.5	5 7
6.5	4.87	3.25	1.62	5 32
7.	5.25	3.5	1.75	5 58
7.5	5.62	3.75	1.87	6 24
8.	6.	4.	2.	6 49
8.5	6.37	4.25	2.12	7 15
9.	6.75	4.5	2.25	7 40
9.5	7.12	4.75	2.37	8 6
10.	7.5	5.	2.5	8 32
10.5	7.87	5.25	2.62	9 17
11.	8.25	5.5	2.75	9 23
11.5	8.62	5.75	2.87	9 48
12.	9.	6.	3.	10 14
12.5	9.37	6.25	3.12	10 40
13.	9.75	6.5	3.25	11 5
13.5	10.12	6.75	3.37	11 31
14.	10.5	7.	3·5	11 56
14.5	10.87	7.25	3.62	12 22
15.	11.25	7.5	3.75	12 48

The Table of relative Gradients is inserted for use in cases wherein the cross section rises too severely, although regularly to be taken at one operation with the level. It affords an opportunity of determining the inclination per chain by means of an inclination taken at a less distance and renders results so taken at once applicable to the general Tables. The corresponding angle affords an opportunity of determining the inclination of the cross section by means of an angular instrument, if such a method pleases the surveyor.

We have now arrived at the stage for the preparation of the Land Plans. The several widths required for the formation of the railway, with a sufficient addition for the bank and ditch, are laid off on the large scale plan, and the several quantities of land required out of each field are computed. These quantities admit of checking by a very simple mode at any given length of line, when the widths have been calculated by my Tables, it being only necessary to multiply the average width by the length. And again, my Tables of Land Measure will obviate this multiplication.

Plate 10 is a Specimen Land Plan.

The contents of railway cuttings and embankments are, in most cases, found by tables, calculated for the purpose. Mr. Baker has recently gone fully into the subject, and as the author of some Tables thereon, I extract his own statement in full.

He says, numerous Tables exist for this purpose, some of which are voluminous; those by M'Neill, Bidder, Huntington, Hughes, Bashforth, Sibley and Rutherford, Law and Lowe, are well adapted for the purpose, assuming the surface line of the cross sections to be level, or to be reduced to that position; but none of these tables will properly apply to sectional areas, which is the most important part of their use, excepting Bashforth's; *but his method of using them is erroneous, the error approximating to* 50 *per cent as a maximum.* I would therefore recommend for this purpose, the *General Earthwork Table,** in conjunction with *Two Auxiliary Tables,* on the same sheet, in *Baker's Engineering,* as being applicable to all varieties of ratio of slopes and widths of formation level in common use; and with the help of *Barlow's Tables of Square Roots,* these tables will apply to sectional areas, with all the mathematical accuracy that can be attained, with very little more calculation than adding the contents between every two cross sections, as given by the General Table.—The contents in the

* The numbers for the side slopes, forming the alternate lines in *Bidder's Table,* will supply the place of the General Table.

General Table are calculated to the nearest unit, as are also those in the Auxiliary Table, No. 2, which is for the decimals of feet in the depths. The Auxiliary Table, No. 1, shows the depths of the meeting of the side slopes below the formation level, with the number of cubic yards to be subtracted from the contents of the General Table for each chain in length, for eight of the most common varieties of ratio of slope.

Note 1.—These Tables, with very little additional calculation, may be extended to every variety of formation level and ratio of slopes that can occur, and even to cases where that ratio differs in the two sides of the same cutting, as shall be shown in the following Problems.

Note 2.—The investigations of the method of forming these tables and using them are given in *Baker's Railway Engineering*, also further investigations are given, at the end of the following Problems, respecting *Mr. Bashforth's Erroneous Methods of Calculating Earthwork.*

The following explanations will further illustrate the method of taking the dimensions of railway cuttings, preparatory to using the above named tables.

Let A B D C *c a b d*, fig. 173*i*, be a railway cutting, of which A B D C, *a b d c* are the cross sections, AB = *ab* = width of formation level, M M′, *m m′* the middle depths of the two cross-sections; the side-slopes A C, B D, *a c*, *b d*, when prolonged two and two, will intersect at N and *n*, at which points the prolongations of M M′, *m m′* will also meet, thus constituting a prism A B N *n a b*, the content of which is to be deducted from the whole content, given by the General Table, by means of the Table, No. 1; in which the depth M′N = *m′n* is also given, as already stated, to several varieties of slope and bottom width.

To place this subject in a more practical point of view, let figure 173*k* represent a longitudinal and vertical section of a cutting, passing through the middle A E of the formation level. H I, the line of the rails, and *a h*, the line in which the slopes, if prolonged, would meet. It will be seen that the cutting A *b c d* E commences and runs out on the formation level A E, and that the depth A *a* = B *e* = C *f* = &c. is to be added to the several depths B *b*, C *c*, D *d* of the cutting, the first and last depth at A and E being each = 0; or, what amounts to the same thing, the several depths must be measured from the line *a h*: thus, A *a*, *b e*, *c g*, &c. are the depths to be used. And since the depth A *a* is given in Table, No. 1, for all the most common cases, or it may be readily found by calculation for all cases,

as shall hereafter be shown, the line corresponding to *a h* must, therefore, be ruled on the railway section, at the proper distance below A E, from which the several depths must be measured; or the vertical scale may be marked with Indian ink (which may be readily rubbed off) at the same distance, and this mark may then be applied to the formation level A E, for the purpose of measuring the several depths.—In the case of an embankment, the line for the several depths must be placed at a like distance above the formation-level.

PROB. I.—*The several depths of a railway cutting to the meeting of the side slopes, its width of formation level, and the ratio of the slopes being given, to find the content of the cutting in cubic yards, from the Tables referred to, the distances of the depths being one chain each.*

Rule.—Take the several quantities, corresponding to every two succeeding depths of a cutting or embankment, measured to the meeting of the side slopes, at the distance of one chain each, from the General Table in *Baker's Railway Engineering* and multiply their sum by the ratio of the slopes; from the product subtract the cubic yards, corresponding to the given bottom width and ratio of slopes from Table, No. 1, multiplied by the whole length of the cutting, and the remainder will be the content of the cutting in cubic yards.

But when the distances of the depths are greater or less than one chain, the quantities of the General Table must be multiplied by their respective distances.—And, when the distances are given in feet, the quantities must be multiplied by those distances, and the final result divided by 66 for the content in cubic yards, as in the following examples.

Examples.

1. Let the depth of the railway cutting or embankment to the meeting of the side slopes, at the end of every chain, be as in the following table, the bottom width 30 feet, and the ratio of the slopes as 2 to 1; required the content in cubic yards.

Note.—In the annexed table the quantity 1238, corresponds to the depths 10 and 33 feet in the General Table; the quantity 3175 to the depths 33 and 39, and so on for the succeeding depths. By the Auxiliary Table, No. 1, it will be seen, that the depth to be added below the formation level, for

Dist. in chains.	Depths in feet.	Qnts. per G. Table.
0	10	
1·00	33	1238
2·00	39	3175
3·00	35	3350
4·00	10	1365
For slope 1 to 1 .		9128
		2
2 to 1 .		18256
Subtract 275 × 4	=	1100
Content in cubic yds.	=	17156

the given width and ratio of slopes, is $7{\cdot}50 = 7\frac{1}{2}$ feet, therefore, the cutting begins and ends with a depth of $10 - 7\frac{1}{2} = 2\frac{1}{2}$ feet. The corresponding number of cubic yards, to be deducted for each chain in length, is multiplied by 4 chains, the whole length of the cutting, thus giving the whole quantity to be deducted, the remainder being the true content in cubic yards of the cutting.

2. The several depths of a railway cutting to the meeting of the side slopes are as in the annexed table, the bottom width being 30 feet, and the ratio of the slopes $1\frac{1}{2}$ to 1; required the content of the cutting.

Dist. in chains.	Depths in feet.	Products for Dist. greater than 1 chain.	Total quantities.
0	10		
1·00	16		420
2·00	20		795
4·00	25	1243 × 2	2486
5·00	32		1996
7·00	39	3091 × 2	6182
8·00	45		4319
10·00	50	5520 × 2	11040
12·00	40	4971 × 2	9942
13·00	30		3015
14·46	10	1059 × 1·46	1546
For side slopes		1 to 1	41741
———		½ to 1	20870
———		$1\frac{1}{2}$ to 1	62611
		366·67 × 14·46 =	5302
		Content in cubic yards	57309

Note.—When any of the distances between two succeeding depths is greater or less than 1 chain, the corresponding quantity from the General Table must be multiplied by that particular distance; as the distances between the depths 20 and 25, and between 32 and 39, &c. the distances being 2 chains. The last distance, viz., that between 30 and 10, is 1·46; in this case 2 figures must be cut off for decimals, after multiplying.

3. Let the depths of a railway cutting to the meeting of the side slopes, and their distances in feet be as in the annexed table, the bottom width 30 feet, and the ratio of the slopes $1\frac{1}{2}$ to 1; required the content in cubic yards.

Dist. in feet.	Depths in feet	Quantities multiplied by length.	Total quantities.
0	37		
90	50	4660 × 90	419400
178	61	7554 × 88	664752
278	39	6210 × 100	621000
For slopes		1 to 1	1705152
———		½ to 1	852576
———		$1\frac{1}{2}$ to 1	2557728
		366·67 × 278 =	101933
			66) 2455795
		Content in cubic yards	37209

Note.—When the distances are in feet, the quantities from General Table must be respectively multiplied by their distances, the quantity from Table, No. 1, by the whole distance, and the result divided by 66, the feet in 1 chain, for the content in cubic yards, as in the annexed operation.

PROB. II. CASE I.—*The areas of two cross sections of a railway cutting to the intersection of the side slopes, its length in chains, bottom width, and ratio of the slopes are given; required the content of the cutting in cubic yards.*

Rule.—With the square roots of the given areas, as depths, find the content from the General Table, as in the last Problem, from which subtract the quantity answering to the given width, and the ratio of sides slopes from Table, No. 1, and the remainder, being multiplied by the length, will be the content required.

Note.—If the length be given in feet, proceed as in Example 3, last Problem.

Example.

1. Let the two sectional areas of a cutting be 4761 and 1296 square feet, the bottom width 36 feet, the length 3·25 chains, and the ratio of the side slopes 2 to 1: required the content in cubic yards.

$\sqrt{4761} = 69$ $\sqrt{1296} = 36$ } content per General Table . .	6959
For bottom with 36 and slopes 2 to 1 per Table, No. 1	396
Content for 1 chain in length	6563
	$3\frac{1}{4}$
	19689
	1641
Content for 3·25 chains	21330 cubic yards.

CASE II.—*To find the content when the depths are given in feet and decimals of feet.*

Rule.—Let a and b be the feet in any two succeeding depths, and α and β their respective decimal parts; find the quantity answering to a and b from General Table, as in the former cases: then,

$2a + \beta$, rejecting the last figure, and α will shew the number to be added in Auxiliary Table, No. 2, and

$2b + \alpha$, rejecting the last figure, and β will shew the number to be added in the same Table.

After which deduct for the quantity below the formation level, as before.

Example.

Let the sectional areas be 1406 and 2560 square feet, the bottom width 36 feet, length 4 chains, and ratio of slopes $1\frac{1}{2}$ to 1; required the content in cubic yards.

Here $\sqrt{1406} = 37{\cdot}5$ and $\sqrt{2540} = 50{\cdot}4$. Put $37 = a$, $50 = b$ ·5 $= a$·4 $= \beta$; then the depths a and b, per General Table, give 4660

$2a + b = 124$, or 12, (by rejecting last figure) and $\beta = {\cdot}4$, per Table, No. 2 give . . . 39

$2b + a = 137$, or 14 nearly, (by rejecting last figure) and $a = {\cdot}5$ give . . . 57

4746

For bottom width 36 and ratio of slopes $1\frac{1}{2}$ to 1 deduct 528

Content for 1 chain in length 4218

4

Content for 4 chains in length 16872 cubic yds.

CASE III.—*In measuring contract work where great accuracy is required, the* $\frac{1}{000}$*ths, of a foot, or second decimals, must be used in the calculation, by taking for them* $\frac{1}{10}$*th of their respective quantities in Table, No.* 2.

Example

The areas of seven cross sections of a railway cutting to the meeting of the side slopes, and their distances are as in the annexed table; the bottom width is 30 feet, and the ratio of the slopes $1\frac{1}{2}$ to 1; required the cubic yards in the cutting.

Dist. in Chains.	Areas in sq. feet.
0	2727
2·00	3136
6·00	4221
9·60	4100
14·00	5141
16·00	3759
18·00	2161

Ans. The content, per General Table, and Table, No. 2, is 172318 cubic yards from which the quantity corresponding to the given bottom width and ratio of slopes × by the whole length, viz. 275 × 18 = 4950 cubic yards, must be deducted, which leaves 167568 cubic yards, the content required.

Note 1.—When the distances of the sectional areas are given in feet, the quantities of the General Table must be multiplied by their respective distances, and the final result divided by 66, as in Example 3. Prob. I.

Note 2.—When the surface lines of the sectional areas are either level or are readily reducible to that position, the decimals, if any, in depths must be taken into the calculation, as in Cases II and III.

PROB. III.—*To adapt the General Table to such widths of the formation level and ratios of slope as are not found in Table, No.* 1.

Put $\omega = \frac{1}{2}$ width of formation level, and $r : 1$ the ratio of slope.

Then $\frac{\omega}{r}$ = feet to be added to the depth of cutting below formation level.

And $\frac{22\,\omega^2}{9\,r}$ = cubic yards to be subtracted for each chain in length.

Example.

Let the width of formation level be 26 feet, and the ratio of slopes $1\frac{1}{4}$ to 1; then $\omega \div r = 13 \div 1\frac{1}{4} = 10{\cdot}4$ ft. = distance below formation level to meeting of slopes.

And $22 \times 13^2 \div 9 \times 1\frac{1}{4} = 330{\cdot}5$ cubic yards to be deducted for each chain in length from the contents of the General Table.

PROB. IV.—*To find the content of a cutting when each of the sides have two different ratios of slope.*

Rule.—When the cutting A B C D (fig. 173*l*) has two different slopes, as A *a* or B *b* and *a* C or *b* D; it must be divided into two parts by the line *a b*, and the quantities of the parts A B *b a*, *a b* D C of the cutting must be found separately by Prob. I. If the surface line C D be sloping or curved, Prob. II. will also be required; and, if the depths *m' n' m* N and their corresponding quantities of cubic yards are not found in Table, No. 1, they must be found by Prob. III, the sum of the contents of the two parts being the required content of the cutting.

Note.—Cuttings of this kind are often advantageously adopted, where their upper parts are of loose or springy earth, and their lower parts strong clay or rocky.

PROB. V.—*To find the content of a cutting when the ratio of the slopes of the two sides are different.*

CASE I.—*When the surface is level.*

RULE.—Find the central depths to the meeting of each of the side slopes, and take their corresponding contents by Problem I for the whole length of the cutting, in the same manner as if it were for two cuttings, and, from the sum subtract the sum of the cubic yards corresponding to the given bottom width and ratios of slope multiplied by the whole length of the cutting, and half the difference will be the content required.

CASE II.—*When sectional areas are given.*

RULE.—Find the contents corresponding to the sectional areas to the meeting of the side slopes by Prob. II, and from their sum

deduct $\frac{44\ \omega^2\ l}{g\ (r + r')}$ cubic yards for the content. In this formula $\omega = \frac{1}{2}$ bottom width, l = whole length of cutting, and r and r' the first terms of the ratios of the side slopes.

Note.—Cuttings with slopes of this kind are frequently adopted in practice, where the ground is springy on one side of them, the greater ratio of slope being on the springy side.

PROB. VI.—*To find the quantity of the cutting of a tunnel.*

RULE.—Multiply continually together the width, mean height and length; divide the product by 9, if the length be given in yards, but if the length be given in chains, multiply the product by 22 and divide by 9, the width and height, in both cases, being given in feet.

Note.—Examples are not given in the three last Problems, the methods of solving which being sufficiently obvious from the Rules and the first three Problems.

THE FOLLOWING EXAMPLES SHOW THE ERRORS OF METHODS PUT FORTH BY MR. BASHFORTH AND OTHERS, TO FIND THE CONTENT OF CUTTINGS.

Examples.

1. The areas of two cross sections of a cutting to the meeting of the intersection of the side slopes, are 1296 and 361 square feet, their distance one chain, the bottom width 36 feet, and the ratio of the slopes 1 to 1; required the content of the cutting by the true and the erroneous methods practically used.

(1.) *By the true method:*—

$\sqrt{1296} = 36$
$\sqrt{361} = 19$ } content by General Table 1907

Deduction from Table, No. 1. 792

True content for 1 chain in length . . 1115 cubic yards.

(2.) *By Mr. Bashforth's method:*—

By Table, No. 1, the depth of the meeting of the side slopes below formation level is 18 feet; hence the area of the triangle below it is $36 \times 9 = 324$ square feet, which, being taken from the given sectional areas, will give 972 and 37 square feet for the areas used by Mr. Bashforth; whence,

$\sqrt{976} = 31{\cdot}18$
$\sqrt{37} = 6.08$ } content by General Table, &c., 975 cubic yards.

This content taken from the true content, given above, leaves 140 error in defect.

Whence 975 : 140 : : 100 : 14·36, or *above* $14\frac{1}{3}$ *per cent. the error in defect by Mr. Bashforth's method.*

2. Let the areas of the two cross sections to the intersection of the slopes be 324 and 2916, and the other things as in the last example, required the content of the cutting by the correct and erroneous methods.

(1.) *By the true method.*

$\sqrt{2196} = 54$
$\sqrt{324} = 18$ } content by General Table . . 3432

Deduction from Table, No. 1. 792

True content for 1 chain in length 2640 cubic yds.

(2.) *By Mr. Bashforth's method :—*

Here the sectional arcs used are 2592 and 0, whence

$\sqrt{2592} = 50{\cdot}91$
$\sqrt{0} = 0$ } content by General Table 2112 nearly, which taken from the true content leaves 528 error in defect.

Whence 2112 : 528 : : 100 : 25 *per cent., the error in defect in this case.*

By taking a mean of the areas in Example 1.

$\frac{1}{2}(972 + 37) \times \frac{22}{9} = 1223\frac{7}{9}$ cubic yards, *which exceeds the true content* $118\frac{2}{9}$ *cubic yards, being about* $9\frac{7}{9}$ *per cent. in excess.*

By taking a mean of the areas in example 2.

$\frac{1}{2}(2592 + 0) \times \frac{22}{9} = 3168$ cubic yards, *which exceeds the true content by* 528 *cubic yards, being* $16\frac{2}{3}$ *per cent. in excess.*

Note.—By taking a mean depth the error in defect is just half the preceding one, or $8\frac{1}{3}$ per cent. These methods only give a near approximation to the true content, when the sectional areas of a cutting are nearly equal. See the results of the following formula and remarks.

The above examples show with sufficient clearness the inaccuracy of Mr. Bashforth's method; but since it has been defended, *as sufficiently correct for practical purposes,* the following formula

will more rigidly prove its failure. Let A′ and B′ be the sectional areas of a cutting, as used by Mr. Bashforth, and a the area between the formation level and the meeting of the slopes; then by *Baker's Railway Engineering*, page 55, $\frac{1}{81}$ ($\sqrt{\text{A}' + a \times \text{B}' + a} - \sqrt{\text{A}' \times \text{B}' - a}$) = his error in defect, the content by his method being $\frac{1}{81}$ (A′ + B′ × $\sqrt{\text{A}' + \text{B}'}$), the length being unity; whence $100 \left(\sqrt{\text{A}' + a \times \text{B}' + a} - \sqrt{\text{A}' \times \text{B}' - a}\right)$ / (A′ + B′ + $\sqrt{\text{A}' \times \text{B}'}$) = error per cent. by Mr. Bashforth's method.

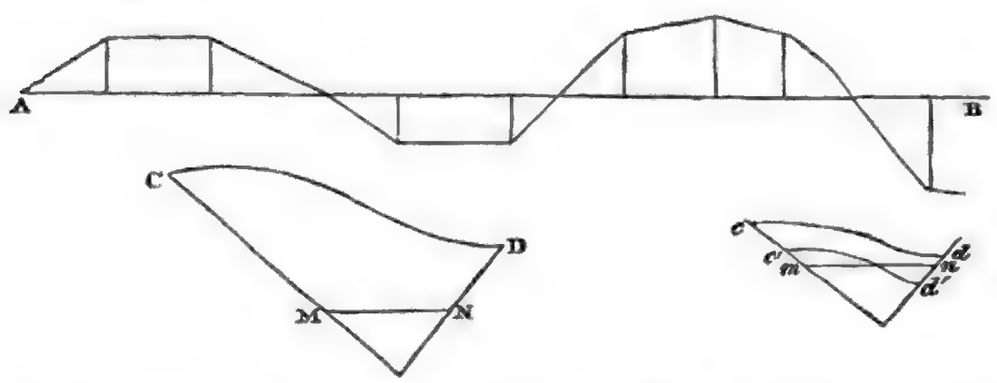
Examples.

1. When $\text{A}' = \frac{1}{9}\ a$ and $\text{B}' = 9\ a$, the above formula gives $100 \left(\sqrt{\frac{1}{9} \times 10} - \sqrt{\frac{1}{9} \times 9} - 1, a\right) / \left(\frac{1}{9} \times 9 + \sqrt{\frac{1}{9} \times 9},\right) a = \frac{10}{3} - 2 \Big/ 10\frac{1}{9} = \frac{1200}{91} =$ $13\frac{1}{6}$ *per cent. error in defect.*

2. When A′ = 0 and B′ = 3 a, the above formula gives, $100 \frac{(2 - 0 - 1)}{3} = 33\frac{1}{3}$ *per cent. the error in defect.*

3. When A′ = 0 and B = a, *the error in defect is* $41\frac{2}{3}$ *per cent.*

Errors of this kind will repeatedly occur in practice, where cuttings and embankments are made, as in the following figure; wherein A B is the formation level, and the corresponding curved line is a section of the earth's surface; the small figures below being cross sections taken to the intersection of the slopes, in which M N, m n, represent the formation level, the sectional areas, used by Mr. Bashforth, being those above the lines M N, m n, the cross section c d m n may either be very small, as in Example 1, or 0, as in Examples 2 and 3; in which latter cases the surface c' d' of the section cuts m n.



From the above figure it will at once be seen that more than one-

half of the sectional parts of the cuttings and embankments will be affected by errors in defect of an average of the above-named percentages, which are most decidedly prominent; and sufficient, in many cases that occur in practice, to take away more than the whole of a contractor's profits.—The error of Mr. Bashforth's method attains its *maximum, which is* 50 *per cent.*, when both the sectional areas A′ B′ vanish, which, however, is a case that can never occur in practice.

I have given Mr. Baker's comparisons at length, because he complains in his *Rudimentary Treatise on Land and Engineering Surveying*, that notwithstanding the errors he has proved to exist in the method given by Mr. Bashforth, for finding the contents of cuttings, that gentleman accuses him of copying. Now, had this been the case, Mr. Baker observes, he must also have copied the errors, that is, he ought to have adopted Mr. Bashforth's method of finding the contents of cuttings, from sectional areas, where the surface of the ground is laterally sloping or curved, in which method the prism below the formation level is left out of the question, whereas Mr. Baker has included it in his calculations.

Moreover, Mr. Baker asserts that his method was communicated to several gentlemen long before the publication of Mr. Bashforth's method, among whom was Professor Tate, of the Training Institution, near Twickenham, who is a competent judge of such matters, and who has himself published on the same subject in his *Geometry*. As for the General Table, Mr. Baker defends it by saying it is calculated from one of the same formulæ, used by Sir John McNiell, Mr. Bidder, and others, as the basis of their Tables, and must, therefore, be common property.

Tunnelling is generally adopted on a railway when the cutting would require to be more than about 60 feet. It is desirable that the gradient in a tunnel should have a fall in one direction, for the purpose of allowing the water generated therein to be discharged by the natural force of gravitation. If the tunnel is very long, a fall may be given to the gradient from the centre towards either end. A tunnel on a curve requires to be very accurately set out, as well as levelled, or very great embarrassments may arise in its construction.

The mining operations in a tunnel are directed by a miner's compass. The direct bearing of the line, if straight, or of the tangent of the curve, if in a curve, being taken at the top of a shaft, and laid out in the same direction at the bottom. Experience in the use of instruments is required in these operations, to detect any concealed attraction of the needle, or other instrumental errors that may so easily occur. It must be borne in mind, that the forma-

tion line in a tunnel is much below an ordinary cutting, inasmuch as there is generally an inverted arch to be turned beneath the ballasting, except indeed in those strata that are of themselves sufficient to maintain the shape of the tunnel.

The following notes on the construction of tunnels, are extracted from *Dempsey's Practical Railway Engineering.*

NOTE 1. Like mining and all other subterranean operations, the construction of a tunnel can be but little aided by mechanical appliances; it chiefly requires hard manual labour, exercised under circumstances which do not admit of that thorough superintendance which promotes economy, and, moreover, liable to unforeseen interruptions, of surmounting which neither the manner nor the expense can be predetermined. Thus the Kilsby tunnel, on the North Western Railway, was estimated to cost £40 per yard lineal; whereas the actual cost was £130 per yard, owing to its intersecting a quicksand that had escaped the trial borings. Thus a vast expense was incurred in setting up and working pumping machinery to dry the sand. The Box tunnel on the Great Western Railway, excavated through oolite rock, and lined with masonry only through a portion of its length, cost upwards of £100 per lineal yard. The length of this tunnel is 3123 yards, or upwards of 1¼ miles; it has eleven principal shafts, and four intermediate ones. The Bletchingley and Saltwood tunnels, on the South Eastern Railway, cost respectively £72 and £118 per lineal yard, the greater cost of the latter work arising from the great body of water in the sand which it intersects.—The method of proceeding with tunnelling depends mainly upon the kind of material to be excavated. This having been generally ascertained by boring and trial shafts, which must be sufficiently capacious to admit readily of lowering men and materials, raising materials excavated, fixing pumps, and also for starting the headway of the intended tunnel when the required depth is reached.

NOTE 2. The working shafts are made from 8 to 10 feet internal diameter. They are of brick work, usually 9 inches thick, and carried up 8 or 10 feet above the surface of the ground. These, and all other shafts, rest upon curbs of cast iron, fitted into the crown of the tunnel, and forming a level base for the shaft. The air shafts are of a smaller thickness and diameter, the latter of which is usually about 3 feet. —The number of working shafts will depend chiefly on the rate of speed with which the work is required to be accomplished. With plenty of men, horses, material, and plant, the work is much facilitated by sinking extra shafts, which will usually well repay their cost.

NOTE 3. The Watford tunnel, 75 chains in length, on the North Western Railway, was worked with six shafts, about 8 feet internal diameter; the brick work was moulded to fit the circumference of the shafts, and laid in two half-brick rings. Air shafts were sunk at about 2½ chains distance on each side of each working shaft. The arch and side of the tunnel were chiefly made two bricks thick, and the invert, one and a half brick, except where the stratum passed through seemed to suggest an increased or diminished thickness. The form of the top of the tunnel is nearly semi-circular, supported by curved side walls standing on side footings, or skew backs, which rest on the invert.

SPECIFICATION.

SPECIFICATION to be observed by the *Contractor* for the works to be executed upon the railway, commencing at a peg numbered 1901 on the plans of the said railway, and terminating at a point where the said new railway forms a junction with the main line in the parish of ———, being a distance of three miles and sixteen chains, or thereabouts.

It includes the formation of the railway, with all the excavations and embankments complete; the drains, fences, gates, and other works connected therewith; and the erection of the following bridges, [*here set forth fully a description of the bridges,*] together with the formation and completion of the several approaches thereto, and roads over them.

The building of the culverts, in the position shown in the plan and section, and of the dimensions there given, together with all the necessary diversions of the streams and drains to lead the water into and from the culverts; the laying and ballasting of the permanent way; the providing of all timber, bricks, lime, stone, or other materials necessary for the completion of the works in a sound, substantial and workmanlike manner; the excavations of the occupation bridges, occupation roads, and diversions, marked upon the plan and section, and of all other works mentioned and described in the accompanying drawings and specifications, and the keeping of the whole of the works in a perfect state of repair for twelve months after completion. [*Here must follow a full and minute description of all the drawings.*] The preceding enumerated works, and the mode of execution are described at length in the specification of each particular work, and their forms and dimensions described in the accompanying drawings, which are referred to in

each specification; but should any discrepancies exist between the measurement by the scale attached, and the written dimensions, the latter are to be taken as correct, any thing contained in the drawings or specification shall be considered as contained in both.

Written dimensions to be taken.

The written dimensions are those by which it is intended the contractor shall make his estimate.

All minor parts to be included, though not described.

And wherever neither the drawings nor the specification contain any notice of minor parts, the intention to include which is nevertheless clearly to be inferred, and which parts are obviously necessary for the completion and stability of the work, all such additional parts are to be provided by the contractor, and are supposed to be included in the sum at which he contracts for the works, and wherever any thing is directed to be done, or to be provided, if required, or words of similar import, it must be understood that every thing so referred to will be considered as included in the contractor's tender.

Contractor to nick out slopes of excavations and embankments.

The centre line of railway is staked out on the ground, but the contractor must at his own expense nick out the slopes of the excavations and embankments, as also the exterior of the ditches previously to the commencement of any of the works, and provide the engineer with all necessary assistance in setting out and measuring off work during the continuance of this contract.

Contractor to adhere to provisions of Act of Parliament.

The contractor will in all cases be required to strictly adhere to the provisions contained in the Act of Parliament, for making this railway, as he will be held responsible for all claims which may be brought against the Company in consequence of any infringement of the stipulations therein contained.

Trees that are felled on line to be barked.

All trees that are in the line of the railway, and which require to be felled, must, if the season permit, be carefully barked, and the bark properly stacked.

Fencing and Ditching.

Fencing of two kinds.

The fencing and ditching described in the following specification is of two kinds, the first, temporary, for the protection of lands adjoining the railway, during the progress and until the completion of the works; the second the permanent for the enclosure of the railway when finished.

Temporary Fencing.

Temporary Fencing.

Immediately after the delivery of any portion of the site of the intended railway into the possession of the contractor, and previous to the commencement of the other works, the temporary fencing shall be completed, and shall include the whole area of land belonging to the company, as also all land occupied by any of the works contained in this contract; and gates and slip rails shall be so placed as to afford a convenient occupation of the adjacent lands, for the convenience of cartage of materials, and a general passage along the line; openings shall be made in the cross fences and gates or slip rails erected for more effectual prevention of trespass, and the contractor shall be held liable for all damage done to the adjoining lands by cartage of materials, or by the straying of horses, cattle, or other beasts that may happen by his neglect, or by that of his agents or workmen, in not maintaining the fences or gates, or otherwise; and the contractor shall, without delay, when required, make good any fence, or gate, or railway, that may have been destroyed or injured, from whatever cause, and shall preserve the most effectual security to the cattle grazing in the land adjoining, in neglect of which the engineer shall have full power to pay all claims for trespass to the proper parties, and to deduct the same from the account due to the contractor at the next or any subsequent payment.

Gates and Slip Rails to be placed to afford convenient access to lands.

Temporary fencing described.

The temporary fencing shall consist of split oak posts placed nine feet apart, and three and a half feet high above the ground, morticed for the reception of three horizontal oak or larch rails, which are to be supported by an intermediate stay or prick post, firmly nailed to each of the rails.

Permanent Fencing.

Drawing, No. 16.

Permanent fencing.

The permanent fencing will consist of post and rail fencing, ditches and quicksets, and must be placed within the limits of the slip of land allowed for this purpose, beyond the termination of the slopes.

Ditch.

A ditch of three feet wide at the top and one foot wide at the bottom, and twelve inches deep, shall be made

upon the higher side of the ground occupied by the railway, and a ditch three feet wide at the top, one foot wide at the bottom, and one foot six inches deep on the lower side of the ground.

These dimensions shall be increased or diminished, as in the opinion of the engineer the circumstances may require, so as to produce an effectual drainage and keep the water out of the excavations, and carry it away from the foot of the embankments, and where necessary, the existing drains and ditches must be deepened to obtain a sufficient fall.

Company's property. The outer slopes of the ditch must, in all cases, correspond with the boundary of the company's property.

Drains. All drains, or alterations, or deviations in existing drains, or water courses necessary for the exclusion of the water from the cuttings, or for the prevention of drainage to the adjoining property, or any other property whatsoever, shall be made by the contractor at his own expense.

Mound or Cop. The material excavated from the ditch shall be used to form a mound on the space between the edge of the ditch and the railway slope, and the side adjoining the ditch shall be neatly ramparted with turf sods, which shall not exceed four inches in thickness, to be ten inches wide, and eighteen inches long.

When the material excavated from the ditch shall be more in quantity than sufficient to form the mound, the surplus must be conveyed to the nearest embankment.

Quicks. The best portion of the vegetable soil excavated from the ditch shall be placed in the middle of the mound, on which a row of three years old good quicksets shall be planted, and not less than nine quicksets shall be contained in one lineal yard; on the inner edge of the ditch, oak posts and rails must be set to protect the quicksets.

Posts. The posts are to be of split oak or good larch, six feet six inches in length, and equal to at least five inches by three and a half in sectional area; they are to be placed at a distance of nine feet, from centre to centre, and to stand four feet above the surface of the land.

Each post is to have three mortices for the reception of the ends of the rails, which are to be made of split oak or larch, and to be as straight and nearly of an uniform size as possible.

Rails. The horizontal rails, three in number, between each pair of posts, are to be of oak or larch, not less than four inches in sectional area at the small end, and ten feet in length, and the ends are to be scarfed so as to fill the mortices of the posts.

Prick Posts. Midway between the posts an oak or larch stay five feet six inches long, and two and a half inches square, being driven into the ground, at least eighteen inches is to be firmly nailed to each of the three horizontal rails with good tenpenny nails.

Hoops. The posts must be firmly fixed, by being set in the ground without being sharpened, the ends of the rails properly fitted into the mortices of the posts, and a piece of new iron hoop one inch and a quarter wide, and one sixteenth of an inch in thickness, shall be nailed round the top of every post to prevent its splitting.

Fencing to be made with as few bendings as possible. The fencing shall be made with as few bendings as the nature of the ground will permit of, and the ditch alongside the mound shall descend as uniformly as possible to the nearest main drain, or watercourse, by which the draining of the adjacent land is at present effected.

The permanent fencing shall proceed as rapidly as the progress of the works and the nature of the season will admit of.

Draining tiles through mound. At the bottom of the embankments small draining tiles shall be laid through the quick mounds at intervals of not more than ten yards, to convey the water draining from the slopes into the fence ditches.

Fencing to be kept in order. Such parts of the permanent fencing as shall have been completed, before the finishing of the other parts of the work, shall be kept in complete order by the contractor.

Quicks to be cleaned, and broken rails replaced. The quicksets shall be cleaned or weeded twice at least in a year, and any broken rails, or posts, or stays replaced by new ones, equal in quality to those originally used.

Dead quicks to be pulled up. All quicksets which may not take root and grow must be pulled up, and three years old living quicksets planted in their stead.

Cross fences to be joined up. The railway fencing must be effectually joined to the cross fences by posts, rails, and quicks, and the mound for the cross fence must be carried over the ditch of the railway by means of a short culvert, of a sufficient size to preserve a free and uninterrupted water-way along the railway ditch.

Fencing to be substantial.

The whole of the fencing, both temporary and permanent, must be firmly and substantially fixed, so as to exclude sheep, pigs, and all other cattle from the excavations and other works, and effectually prevent the adjoining lands from trespass during the progress of the works.

Temporary fences dispensed with in particular cases.

Should the contractor be prepared to erect the permanent fencing on any part of his contract, previous to any interference with the existing fences of the fields, he will be permitted to do so, in which case the temporary fencing may be dispensed with altogether, on that particular part of his contract.

Temporary fencing may be used in the permanent fencing.

Such part of the temporary fencing as can be made available shall be permitted to be used in the permanent fencing, provided the material be of the requisite strength and quality, and uninjured in other respects by its previous use.

Fence walling described.

When stone walls are made use of for permanent fencing they are to be built of good sound red sandstone rock, in block, and course work set in lime of the form and dimensions shown in Drawing, No. —. The stones to be firmly bedded and break joint properly.

Gate Posts, &c.

The gates and posts, &c., are represented in Drawing No. —. The heads and heels are to be made of sound oak or ash morticed to receive the horizontal bars, which together with the diagonal stays and uprights may be of memel timber, sawn or dressed, or of oak, ash, or larch; the hanging and clapping posts must be of oak or stone, if of oak the lower ends are to be charred. The iron work to be of the best quality, neatly fitted up and riveted to the woodwork; the diagonal and upright pieces are likewise to be riveted to the horizontal bars. The whole of the wood to be well seasoned and of sound quality, and to be put together and fixed in a workmanlike manner, and to receive two coats of good oil paint. The contract includes gates, with their posts, covered drains, &c., complete, and comprises about —— lineal yards of single post, rails, and quickset fencing.

If stone gate posts are used the dimensions must not be less than nine feet in length, with a sectional area of $1\frac{1}{2}$ square feet or fifteen inches square.

Excavations and Embankments.

Width of slopes.

The excavations and embankments throughout this contract shall be thirty feet wide at the level of the red line, on the section, neither more nor less, and shall extend at that level to an equal distance on each side of the outside rails when they are finished and laid in their proper line as hereinafter described under the head of permanent way.

The excavations are to be made with the slopes marked upon the section, where it is stated "1½ to 1," it is understood that where the base of the slope is one foot and a half, the height shall be one foot only, and when "2 to 1," that for the base of the slope two feet, the height shall be one foot only.

Slopes to be dressed and sown.

As the cuttings and embankments advance and the latter become consolidated, the slopes shall be carefully dressed or trimmed to the specified inclinations, and as near to the face of the work as possible, and covered with turf or soil, which shall be carefully obtained from the surface of the ground to be occupied by the railway.

The soil must be uniformly laid on of the thickness of six inches, and sown with rye grass and clover seeds, as soon as the proper season will admit of its being done; and not less than one pound and a half of rye grass and one pound and a half of clover seed to be sown on each acre.

When the engineer shall require it, the slopes must be neatly faced with the turf, not less than eight inches in thickness, and laid with the green sward outwards.

In the formation of the excavations and embankments, in this contract, the contractor shall not remove the turf or soil from the ground for a greater distance than half a statute chain in advance of the face of the excavation or embankment, and that which has been cut must be removed back to a point where the slope is ready for receiving it, and laid down as directed with as little delay as possible.

Slopes to be altered if required by engineer.

Should the contractor be required by the engineer to alter the rate of the inclination of the slopes, he shall do so, and a proportionate addition or reduction (as the case may be) shall be made to or from the contract sum, at the average price per cubic yard stated in the schedule.

Borings.

Shafts have been sunk and borings made on the line in

various situations with the view of ascertaining the nature of the material.

The contractor may see the account, but must satisfy himself of its accuracy, as no allowance will be made should the material differ from that account.

Their situations are marked in the general section.

Contractor to find all materials, as waggons, barrows, &c.

In the formation of the excavations and embankments, the contractor must provide all necessary rails, chairs, keys, pins, blocks, and sleepers, as well as waggons, barrows, planks, and other machinery, materials or utensils, which stipulation is however modified to a certain extent by the following conditions.

Delivery of permanent rails, &c. &c.

It is not intended to deliver to the contractor any of the permanent rails, chairs, keys, or pins, until, at least, one continuous mile of railway, together with three hundred yards in continuation of each extremity of such mile, shall have been completed and certified by the engineer as being ready for the reception of the permanent ballasting, as in this contract is hereinafter mentioned: on which certificate, a sufficient number of rails, chairs, keys and pins, shall be delivered to the contractor by the company, and he shall be permitted to use them in such manner only as is hereinafter described in the specification of the laying and ballasting of the permanent way. Provided, however, that such permanent rails shall, in no case whatever, be laid down and employed within three hundred yards of the face of any excavation, or at the end of any embankment then in progress.

Surplus material to be deposited in Spoil Banks.

The surplus material beyond that required for the formation of embankments, approach roads, and other embanking, is to be deposited in spoil banks, in such places immediately contiguous to the line of railway as the engineer may direct, the company giving the contractor temporary possession of the land; the foot of the slopes of the spoil bank in no case being placed nearer than five yards to the top of the slope of the railway excavation; the height of the spoil bank shall in no place exceed fifteen feet above the natural surface of the ground. The sides of the spoil banks are to be sloped at the rate of six horizontal to one perpendicular.

Previous to laying out any spoil bank, the contractor shall give to the engineer notice in writing, together with

a plan, describing the quantity and situation of the land he requires for that purpose.

If so directed by the engineer, the contractor must convey the material to any greater or less distance, according to which, if the cost be thereby increased, he is to receive a greater or less price as specified in the schedule.

Soil to be removed and laid upon Spoil Banks, and the slopes of cuttings and embankments.

The whole of the soil upon the surface of the ground through which any excavation extends, or over which there is any embankment or spoil bank, is to be removed, and afterwards laid upon the slopes of the cuttings and embankments and the surface of the spoil banks, so as to leave the spoil banks in a state fit for agricultural purposes, and the slopes of the cuttings and embankments in a state fit for the growth of grass, or shrubs, either on the line of railway, or on the side of diverted roads or bridge approaches, or in any situation. The thickness of soil and sodding over the whole surface and slopes of the spoil banks must be not less than twelve inches, nor less than eight inches on the slopes of the embankments, and the contractor is to sow the slopes of the embankments and the spoil banks with grass or any other seed which the engineer may direct. The period at which the soil is laid on and the seed sown is to be determined by the engineer.

Slips in Excavations.

All slips which may take place in the excavations, and which are not attributable to the improper mode in which the contractor may have conducted the work, are to be removed by him at the price stated in his schedule: such as are attributable, in the opinion of the engineer, to any improper mode of conducting the work, are to be removed at his own expense, and will be considered as included in the tender.

Embankments.

The embankments are to be made with the slopes stated upon the section, to which the foregoing explanations under the head of excavations will apply.

Embankments.

The embankments are to be formed of the materials obtained from the excavations, and when finished and consolidated they are to be of the height represented by the red line on the longitudinal section, and of the width

Width and Height.

shown on the cross section, viz., thirty feet, being made of such extra height and width in the first instance, as to

allow for the subsidence of the embankment and they are to be made at the full height and width at once in a single battery. The surface of the embankment at the height of the red line is to be made slightly convex.

Embankments to be kept dry.

Every part of the embankment must be kept dry, and no water must be allowed to remain either at the base or upon the surface.

Deficiency of material to be supplied.

Should there be a deficiency of materials in the adjoining cutting to make up any of the embankments, the contractor must make up the deficiency, either by side cutting near the spot, or by increasing the width or slopes of the adjoining cuttings, uniformly, throughout their entire length, as the engineer may determine. The company will provide the contractor with land for this purpose, in such a situation as the engineer may approve, the contractor bringing the surface of the ground to an uniform slope of 6 to 1, and covering it with a layer of sods and soil not less than twelve inches in thickness.

Pitching sides.

In the schedule a price must be named for paving or pitching the sides of the embankment with red sandstone, nine inches thick, the price per cubic yard for the embankments remaining the same.

Slips in Embankments.

In case of slips taking place in the embankments, the contractor will be required to make them up at his own cost.

Earth to be trimmed to slopes and widths at once, and no additions made afterwards.

Whenever the material teemed over the end of the embankment shall not form the proper slope, it shall be carefully trimmed to its required slope, and this operation must proceed at the same time with the end of the embankment, so as to obviate the necessity of any further addition of material to the sides of the embankments.

Large lumps to be broken.

When the material brought to the embankment consists of large lumps, they shall be broken into pieces of not more than six inches in diameter, unless they consist of rock.

A cross section of an embankment is shown in Drawing, No. —.

Disposal of Material.

Throughout the whole of this contract, the material from the excavations is to form the next adjoining embankment as well as the approaches to the bridges, and

paved crossings of every description, and whenever and wherever any excavation shall not be sufficient in quantity to complete the next adjoining embankment and approaches to bridges, or sloped roads, the quantity so deficient must be brought from the nearest excavation which shall have a surplus or otherwise obtained by side cutting at the contractor's own cost, and according to the conditions contained under the head of general stipulations hereinafter given.

Bridges, Culverts, &c.

General Stipulations

Which are to apply to the whole of the bridges, culverts, and other works, wherein the workmanship or materials here described may be used excepting to such work as may be directed otherwise.

Brickwork.

Bricks.

The Bricks made use of thoughout the work shall be hard, sound, well shapen, thoroughly burnt and of uniform size and those used in the face of the work shall be of uniform colour and unless made a year before they are used, every brick shall be well saturated with water before being set.

No broken bricks allowed.

No broken bricks will be permitted to be used either externally or internally unless absolutely necessary as closers, except in case of backing when no course shall contain a greater number of bats than whole bricks.

Grouting.

No difference of workmanship will be allowed in the inside and outside work, every course shall be well grouted, the whole of the joints shall be flushed up solid with mortar, and the outside joints to be neatly pointed and drawn. No joint of mortar shall exceed one quarter of an inch in thickness, and the work shall be laid in English or Flemish bond, as the engineer may direct.

Brick on edge.

In all cases where brick on edge is used as coping, the bricks are to be laid as headers in Roman cement.

Stone.

Stone to be of hard sound quality.

All the stone used for bridges, culverts, or other masonry throughout the contract, shall be of a sound and hard quality, and approved by the engineer and free from spots and flaws of every description.

Ashlar Work.

The Ashlar work shall be laid in courses at least nine inches in thickness, all the beds and joints being chisel dressed throughout. The whole to be square jointed and made to fit close. The courses to be laid in such proportion that there shall be at least one header to every stretcher. No stone shall be less in area of bed than five feet, nor shall the width of any stone be less than one and a half times its thickness, and all the joints to overlap at the least twelve inches.

Beds to be dressed.

The greatest care will be required to have all the beds dressed to accurate planes, and no pinning of any kind will be permitted in any part of the work, the faces shall be fair tooled or left rough with rustic champhered joints as may be directed in the description of each particular work. The beds of the stones in all arches consisting of ashlar shall be carefully dressed to fit the summering of the arch. The whole to be laid in mortar and grouted at every course.

Cramps to be used if directed.

When the engineer shall deem it necessary the work shall be cramped together with iron cramps run with lead; but in this case, the contractor shall be paid extra for the iron work according to the schedule of prices.

Block in Course Work.

Block in course work.

The block in course shall consist of stones in courses at least six inches in the thickness and as nearly of an uniform thickness as practicable. No stone shall be less on the bed than ten inches by fourteen inches, and where rubble or brickwork backing is employed there shall be a through at every six feet in each course so as to bond the whole effectually together. The face beds and ends of each stone shall be carefully hammer dressed to accurate planes, and no pinning of any kind will be allowed.

In all cases where block in course work with rubble backing is employed, the area in any cross section of the work shall contain as much block in course as rubble.

The whole of the block in course work shall be neatly pointed.

Rubble.

Rubble Stones not less than 1-6 of a foot.

The rubble shall be constructed of stones, each containing not less than one-sixth of a cubic foot, to be carefully laid so as to make the closest possible work; when employed as backing, each stone to be bedded in mortar when laid, and the upper surface of the work brought to an uniform level at the height of every course of the face work, and the whole to be well grouted at this level.

Squared up at 18 inches.

When the rubble is not used for backing to the block in course work, the whole may be brought to a level at every eighteen inches in height and then grouted.

A good bond with Ashlar and Brickwork.

In all cases great care must be taken to make close work and effect a good bond with the face, whether it be block in course work, ashlar, or brickwork.

Mortar.

Mortar of Welsh Lime and Sand.

The mortar shall consist of fresh burnt Welsh lime, or other lime approved of by the engineer, and clean sharp sand in the proportion of two measures of sand to one of unslacked lime.

Mixed in a dry state.

They shall be intimately mixed in a dry state, and well tempered with a proper quantity of water, and only mixed as required for use; the mortar that has previously set or become hard upon the ground shall not be permitted to be used in any part of the work.

Water Lime.

If in any situation water lime is ordered to be used, the contractor shall do so without any extra charge; and where the engineer shall deem it necessary, the mortar shall be tempered in a pug mill.

Roman Cement.

Roman Cement.

The Roman cement is to be of the best quality, and shall be mixed with an equal quantity of clean sharp sand. None shall be used which has set or become hard.

Concrete.

Concrete 6 of Gravel to 1 of Lime.

All concrete must be composed of gravel perfectly clean and mixed with fresh well burnt quick lime, in the proportion of six parts of gravel to one of lime.

The proportions are to be accurately guaged and mixed in the dry state, it is then to be moistened and well beaten

until a thorough admixture of all the parts is effected and brought to a tough consistency, when it is immediately to be filled into barrows and teemed from a height never less than eight feet, as near as may be to the place required, so as to need as little levelling as possible, the runs being shifted for that purpose.

To be Levelled at every 18 inches

It is to be brought up in layers not exceeding eighteen inches in thickness, each layer to be completed and brought to a level surface before another layer is commenced; the lime to be fresh burnt, well mixed, and carefully preserved from moisture until actually used.

Arches and Counterforts.

Arches to be laid with Mallet.

The arches, when of brick, shall be laid carefully with a mallet, and built either in concentric half-brick rings, or in such other manner as the engineer may direct; and where counterforts are built upon any part of the arch, they shall be worked into the body of the arch, and their courses shall run in the direction of the radii of the said arch.

Ashlar Quoins.

In all cases where ashlar stone quoins are used in the face of the arch, the greatest care will be required to prevent an unequal settlement.

Any imperfections to be removed.

Great care must be taken in the proper summering of the bricks or stones in each course, and any irregularity of form created by imperfections in the laggings, workmanship, centring, or any other cause, shall be removed and amended by the contractor.

Askew Bridges, courses to be laid in spiral lines.

When the arches are askew, the contractor shall lay the courses in spiral lines, at right angles to the face, whenever he shall be so directed by the engineer; and the beds of the stones forming the arches shall be carefully dressed to the proper twist; also, in all elliptical brick arches, six feet in width measured on each side of the crown shall be laid in Roman cement.

Soffits Pointed.

The soffits of all the brick arches shall be well and neatly pointed.

Backing to Arches.

The Backing shall consist of rubble work, laid in mortar, as before described.

Abutments, Wings, and Spandrils.

Abutments of Brick or Stone as drawings describe.

The abutments, wings, and spandrils will consist either of brickwork or stonework laid in mortar, as before described, and they will be built battering or plumb, as shown on the drawings.

Bricks in Spandrills to be dressed.

The bricks in the spandrils must be neatly cut, or the stone work neatly dressed, so as to fit the extrados of the arch; where the work is battering on the face, the courses shall be laid at right angles to the batter.

Openings to be left in wings.

Small openings shall be left in the lower parts of the abutments and wing walls for the effective drainage of water which might otherwise lodge behind them.

Parapet Walls.

Parapet.

The parapets to be built plumb on each of the sides, the straight part to be perfectly true, and the curvature of that portion upon the wing walls uniform and regular.

The courses to be made parallel to the string course and coping.

Stone Imposts.

Imposts.

Where stone impost or springing courses are used, the stone shall always be equal to the full thickness of the arch, and no stone shall be less than two feet six inches in length, and when required they shall be dowelled and cramped together.

Skewbacks.

In cases of skew arches, the skewbacks must be worked so as to suit the oblique directions of the springing of the courses, and in every course the stones shall be fair tooled all over, excepting at the back which may be left rough.

String Courses and Coping.

String Courses and Coping.

These must be of the form and dimensions shown upon the drawings ———. No stone must be less than two feet six inches in length, and the whole to be throated underneath.

Each stone in the coping must be dowelled and leaded to the adjoining one.

All the surface must be fair tooled or chisel dressed, and the joints made square and to fit close.

Ironwork.

Cast Iron from Cupola.

Wherever cast iron is required to be used, it shall be cast from the cupola, and be of the toughest grey iron, free from air bubbles or pin holes, or any other defect. All the abutting faces must be filed and accurately fitted.

All wrought iron work to be of the best hammered scrap iron.

Iron Work to be tested.

All iron work to be subjected to whatever test the engineer may think it expedient to prescribe, and any defect which may be detected, is to be rectified at the expense of the contractor, and likewise the cost of testing defrayed by him; but the contractor is not exempted by the above provision from the obligation to uphold the work when erected.

Woodwork.

Wood to be Kyanized.

All woodwork in gates, sleepers, &c., and all other woodwork to be subjected to Kyan's patent process, to be of sound memel timber or American pitch pine, free from knots and other imperfections, and to be well seasoned before subjected to Kyan's process, to receive three coats of good oil paint.

All bolt holes to be well charged with thick white paint. All arrisses to be champhered.

Drains under Bridges.

Drains under Bridges.

Drains must be constructed under all the bridges which are in the excavations on each side of the railway, fifteen inches wide at the top, and twelve inches at the bottom, to be sunk as low as the drain at the outside of the ballasting.

Wall 9 inches

They will be formed by a wall of brick or of block in course stone work to support the ballasting, nine inches deep and three feet deep parallel with the abutments, and the length will be equal to the width of the bridge, and as much more as shall be necessary to conduct the water easily in the common side drains.

The whole to be laid in mortar in the same manner as described for the bridges.

Excavatons of Foundation, providing Centring, Filling in over Bridges, and other General Regulations.

Contractor to excavate foundation of Bridges.

The contractor is to excavate for the foundations of all bridges, culverts, and all other works, to keep out the water by coffer dams, if necessary; form drains, do all necessary pumping, and provide all centring, planks, and tools of every description necessary to the perfect execution of the works at his own expense, and they are to be included in the amount of this tender.

If foundations carried lower, extra price as per Schedule.

In case the foundation of any of the works require in the opinion of the engineer to be carried lower than is shown upon the drawing, the contractor is to make such extra excavations, provide extra coffer dams, and to do all extra pumping or other contingent works incident thereto, being paid only for the increased quantity of brickwork or masonry, concrete, or other material according to the prices set forth in the schedule for such description of work.

Foundations.

The foundations must be cut out as nearly to the size of the brickwork or masonry as possible, and the vacant spaces must be carefully punned up to the surface of the ground.

Arches to be puddled over.

The arches of all bridges are to be carefully puddled over their entire surface with a layer of puddle not less than nine inches in thickness; and the space between the wing walls of all the bridges shall be filled in with hard dry material well rammed down where it can be obtained, but when it is necessary to use clay for that purpose, it shall be firmly punned in layers of not more than nine inches in thickness.

Bridges to be balanced.

In bringing an embankment up to a bridge the contractor shall load the bridge equally on both sides, by wheeling the material from the embankment or elsewhere, or by teeming from off the bridge so as to allow of its laying against the abutment, with a slope outward from it, and punning it as previously described, so as to ensure its perfect form and safety.

Stays if necessary to be used.

He shall also take such additional precaution as the engineer may consider necessary, by setting up temporary or permanent stays or shores without making any extra charge.

Water from Bridges to be carried through Piers and Abutments.

In all bridges where there is more than one arch, the spandrills shall be completely drained by means of iron pipes, or the openings cased with brick, in cement, through the centre of the piers and abutments.

String course and parapet not to be put on till directed.

The string course, parapet walls, and coping shall not be put on until after the centres are withdrawn; and in no case shall the centring be struck before permission of the engineer is obtained.

Centring.

All the centring shall be such as shall be approved of by the engineer.

Rails to be laid equi-distant from side walls.

Great care must be taken that each bridge is so placed that the outside rails, when laid in their uniform and proper line, are equidistant from, and parallel with, the faces of the abutments or parapet walls, according as the bridge is over or under the railway.

It is to be understood, that whenever in the drawings, or in any part of the particular specification, the dimension of parts, or the nature of materials, may be directed differently from the above general stipulations, the particular directions are to be complied with.

Approaches to Bridges and Paved Crossings.

Drawings, No. —.

Embanked Approaches.

These excavations and embankments are to be made in the same manner as before described for the main line of railway, and with such slopes as may be directed by the engineer.

The contents of the excavation shall be conveyed to the nearest embankment or spoil bank.

The embankments are to be made from the surplus material in the excavation.

When no surplus exists, then the material shall be procured from side cutting in the nearest excavation, and the contractor to be paid for it at the rate specified in the schedule of prices attached to his tender.

Surplus material to be used to form approaches to Bridges, &c.

But wherever there is a surplus material, the contractor shall employ it to form approaches to bridges or sloped roads, and the cost of so employing it shall be considered a part of his contract, to which the stipulations and prices for extra work do not apply.

Excavated approaches.

The same regulations shall be applicable (where side cutting is required) to the excavation of these approaches.

Approaches to be of height in the Drawings.

All the approaches shall be made of the height, depth, and inclination shewn upon the section of the approaches to each bridge.

Metalling.

The metalling shall in all cases be the width of the bridge between the abutments and parapet walls, as the case may be, and the width of the cutting or embankment shall be five feet more than this at the level of the top of the metalling.

Length.

The length shall be equal to the whole distance of the altered surface as shown in the section of approaches.

Slopes 1½ to 1

All the slopes of both excavation and embankment of bridge approaches being made at the rate of 18 inches horizontal to 1 foot in height.

Embankment to be beaten.

The surface of the embankment when formed, shall be made regular and even, and well beaten with heavy beaters.

2 Coatings of Broken Stones.

First, a cover of brushwood or heath, and then a coating of good gravel or broken stone must be laid over the whole surface eight inches in thickness, and as soon as it shall have become hard by the carriages passing over it, another covering of material, of equal quality with that upon the road at present, shall be laid on seven inches thick in the middle, and four inches thick on each side.

Ruts to be filled up.

The ruts must be filled up from time to time, and the surface kept smooth and even.

To be fenced.

The whole of the approaches which are embanked from either termination of the earthwork to the parapet walls of the bridges must be protected on both sides by wood posts and rails, as shown in Drawing, No. —.

The wood railing must be made of good oak, free from sap, and straight grained.

Rails to be painted.

The rails, and so much of the posts as are shown above the ground, shall be sawn out square, neatly planed, and painted with two coats of stone-coloured paint; all the joints must be made with white lead, and all the wood beneath the surface of the ground well charred.

Two Lines of Posts and Rails.

Those approaches where the line of road and not the level is altered, and also those that are formed by excavating, must be protected on each side and throughout the whole of the extent of the alteration by quickset fencing and ditching, similar to that described for the railway, but having an additional line of posts and rails, namely, one on each side of the quicksets.

Temporary Roads to be provided and fenced during alterations to public Roads.

Previous to the works connected with any bridges, approaches to bridges, approaches to paved crossings, or diversions of roads, which may in any way affect existing roads, being commenced, a good and well-made temporary road shall be provided and maintained for the free and uninterrupted passage of carriages of every description. Every precaution shall be taken by the contractor during the alteration of any road to erect proper fencing, and fix and maintain lights for the protection of travellers, as the company will not be held responsible for any injury which may arise from the neglect of these precautions.

The whole of these observations shall be considered to apply, unless in any particular case they may be directed otherwise.

Paved Crossings.

Drawing, No. —.

Paving Stones.

All the roads crossing the railway without bridges, are to be paved at the intersection with the railway, in the same manner as shown in Drawing, No. —, with good six-inch paving stones of Penmaen Mawr, Dublin, or other granite equally good.

The paving must be laid on a bed of fine clean gravel of six inches in thickness, in a solid and substantial manner.

The paving stones must be cubes as near as possible.

Rails to be protected by Iron Bars.

Each rail must be protected by two iron bars, as shewn in Drawing, No. — ; they will be considered part of the rails, and provided by the company. The present contract is to comprise six of these, and any additional number that may be required shall be executed at a price to be named in the schedule.

Culverts.

Drawing, No. —.

Culverts.

The culverts throughout this contract are to be built in the situations marked upon the general section, of the form and dimensions shown in Drawing, No. —. The size being selected to suit the particular situation.

Directions of Drain to be altered.

Wherever the direction or position of the culvert does not correspond with that of the stream, either in line or level, the stream shall be altered so that the water may be conducted to or from each end of the culverts in the manner best fitted for facilitating the drainage.

Soft Ground to be taken out.

Where the foundations are insecure, the soft ground is to be taken out, and the space filled in with solid dry material, such as the engineer shall approve of, without any extra charge.

Cover of dry material to be laid over Culverts.

All culverts exceeding three feet diameter, shall be covered with dry or hard material two feet above the top, and ten feet on each side; and the part adjoining the culvert, extending to a distance of four feet from the brickwork or masonry, to be well punned in layers of one foot in thickness, before the embankment shall be allowed to come upon it.

Culverts to extend under Fences.

Culverts, under three feet in diameter, are to extend in length under the fence of the railway; each culvert must be built in a direction which may, in the opinion of the engineer, afford a free and uninterrupted passage for the water.

The general stipulations for masonry and brickwork, hereinbefore given, are applicable to these culverts.

Diversion of Roads.

Alterations in Roads.

The alteration necessary to be made in the direction of the existing roads for this contract, exclusive of those which are required in approaching bridges, are shown upon the general plan (Drawing, No. —).

Soil to be taken off.

Where the level of the new roadway is near the surface, the top soil must be removed from the space to be occupied by the road, and the surface made uniform and regular for receiving the metalling.

Metalling.

The material and manner of laying it on to be the same as described for the approaches to bridges, the thickness being twelve inches when a public road, and eight inches when an occupation road.

Where no Fencing or Metalling required.

In cases where, in the opinion of the engineer, no metalling or fencing is required, a deduction will be made of the cost of such metalling or fencing, according to the schedule of prices.

Excavations or Embankments.

Any excavation or embankment that may be necessary,

shall be done by the contractor in the same manner as directed for similar works upon the line of the railway.

Fencing. The fencing shall be similar to that described for the railway, but having an additional line of posts and railing, viz., one on each side of the quicksets.

Ballasting and Laying the Permanent Way.

The railway is intended to form a double way, composed of four single lines of rails.

Planes. The several level and inclined planes are shown by the blue line on the Section Drawing, No. —, which represents the surface of the rails, and the directions on the general plan, (Drawing, No. —).

Curves. The greatest care will be required that the portions shown upon the plan as straight be made strictly so upon the ground, and that the curves are all uniform and neatly brought into the straight lines.

Laying and Ballasting. The laying and ballasting the permanent way is intended to be completed in such portions and at such times as will suit the convenience of the contractor in executing the works.

Previous to the delivery of the materials of the permanent way to the contractor, the surface of the embankments and bottoms of the excavations shall have been made of the proper line, height, and depth, and uniform in width, level, and inclination. They shall be completely drained from all water, and certified by the engineer as being in a fit state to receive the permanent ballasting.

Embankments and Excavations to be drained, &c.

Materials. The materials to be delivered to the contractor will consist of sleepers or blocks, rails, chairs, and fastenings; and he will be held responsible for the replacement in case of loss or injury to the materials thus delivered to him from the time of their delivery till the expiration of this contract.

Delivery of Materials. They will be delivered by the company at some convenient wharf, whence they must be conveyed by the contractor to the works at his own expense. The company will provide the necessary sleepers, a particular description of which is hereinafter given.

Lengths. The rails will be in lengths from 12 to 18 feet; they will be supported at every yard by a cast-iron chair or pedestal, which will be accompanied by wrought-iron keys for fixing

the rails on the chair, and with two pins or spikes for fixing the chair on the sleeper.

The dimensions of each part, and the construction of the whole, are shown on Drawing, No. —.

Broken Stone Ballast.

The material for ballasting shall be composed of broken stone, cinders, or clean gravel, entirely free from any admixture of clay or material retentive of moisture; if broken stone be used, none shall be larger than will pass through a ring two inches in diameter.

Inches thick.

The ballasting shall be spread over the whole surface of the tops of the embankments or bottoms of the excavations between the drains, of an uniform thickness of twelve inches.

Top Layer of Broken Stone.

And as soon as the sleepers have been carefully laid, the intervals between them, and between the outer ends and the edge of the embankment, or the drain at the bottom of the cuttings, are to be filled in to the level of the top of the sleeper with broken stones, equal in quality to those in the bottom bed, and to a height of two and a half inches below the surface of the rail, and the interstices to be filled in with smaller stones, they being beaten down to render the entire width a consolidated mass.

Ballast to be beaten.

This stratum of ballast shall be beaten into a firm and solid mass by heavy beaters, worked by at least two men; and the thickness before mentioned shall be considered to apply only after this operation has been effectually performed.

Upon this surface the sleepers are to be laid in their proper situations for receiving the rails.

Bed of Sleepers to be beaten.

The ballasting intended for the bed of the sleepers shall be beaten by heavy beaters, and each sleeper also forcibly beaten when it has been placed in its position until it has become firmly and uniformly bedded throughout its whole length and reached its proper level.

If too low to be raised.

If it should be found lower than required, it shall be removed, and additional material to be placed in its bed; the same process as before must then be renewed until it has reached its proper level.

Rails to be laid level.

The rails must be laid at the proper level and inclination, and at the proper bevil to fit the cone of the wheels, to be perfectly parallel, and at the same height at any one point; the joints must be made perfectly even, whether square, half-lapped, or scarfed, and be firmly secured in the chairs.

Lines to be 6 feet apart.

The two lines of way are to be six feet apart, and the width between the insides of the rails of each way four feet eight inches and a half.

Sleepers to be chaired.

The wood sleepers must be cut on the upper surface to the proper level for the reception of the chair, which must be firmly fixed on the exact guage, to be furnished by the engineer. The pins shall not on any account be driven into the sleepers without the hole having been previously bored with a proper sized auger.

The rails must be securely fixed in each chair by keys; the chair shall be firmly fixed on the sleeper.

Rails to be straightened.

Any of the rails which may be twisted or bent in the least degree, to be made perfectly straight with proper hammers and anvils, previous to their being laid down.

Contractor may use Gravel out of Excavations, but not occasion deficiency.

The contractor may use any rock, gravel, or other suitable material for ballasting which may occur in any of the excavations included in this contract; but if in so doing he shall cause any deficiency in the material for the formation of the embankments, he shall make up the deficiency by a side cutting in such of the excavations as the engineer may point out, and at his own expense.

Stone taken from Cuttings not to occasion deficiency.

The contractor is also at liberty to obtain stone for bridges, culverts, drains, or other masonry, provided it is of a quality approved by the engineer; but if in so doing he shall cause any deficiency in the material for the formation of the embankments, he shall make up the deficiency by a side cutting, at his own expense, in such of the excavations as the engineer may point out; and if such side cutting shall require an additional quantity of land, the contractor shall indemnify the company for the purchase of the same.

No material to be taken from Embankments.

The contractor shall in no case remove any material from the intended sites of any of the embankments unless permitted by the engineer.

Tile drains.

Tile drains, throughout all the excavations, are to be laid in the ballasting, as shown in Drawing, No. —; one shall be laid in the centre of the ballasting throughout the whole extent of the excavation, and shall have cross drains

To be laid without mortar part in water lime.

at intervals of every five yards, communicating with the drains on either side alternately; they must be properly and securely laid, without mortar, excepting 18 inches in length at the open ends, which shall be laid with water lime.

Receipt for Rails.

The contractor shall give the assistant engineer a receipt stating the number of rails or other materials in each parcel delivered to him and placed in his possession; he shall be accountable for the loss of any part of them; he shall also replace any rails, chairs, pins, blocks, trenails, or sleepers which may have been broken, or otherwise rendered unfit for use while in his possession, or during the progress of the works.

Contractor may make Sidings.

The contractor shall be at liberty to make sidings or crossings from one line of the permanent road to the other, for his own convenience during the progress of the work, provided he does not injure the rails in so doing, and removes them when the works are complete.

Limit to weight carried on temporary waggons.

No waggons, carriages, or engines employed by the contractor on the permanent road, shall have a greater weight placed on any one axle than three tons, unless the engine or carriages are placed on good and sufficient springs; and when they are so mounted, the weight on any one axle shall not exceed four tons.

Permanent way to be maintained.

Such portions of the permanent road as are used by the contractor in conveyance of material from the excavations (according to the stipulations already described under that head,) or for any other purpose, shall be carefully attended to, and kept well drained, and in good repair, and adjustment.

No Sleeper to be used if injured.

No sleeper which has been used in any temporary road during the progress of the work shall be made use of in the permanent road, unless such shall have been inspected and pronounced sufficient by the engineer.

Wooden Sleepers.

The sleepers to be of larch, oak, pitchpine, or teak.

Sleeper to be 9 feet long.

Larch sleepers to be cut from sound trees, slowly grown; each sleeper to be nine feet long by 10 inches wide and five inches thick, at the centre of the smaller end, being a pole of larch ten inches in diameter (exclusive of bark,) at the smaller end, and nine feet long, sawn up the middle.

Oak, Larch, or Teak.

When sleepers are cut from oak trees not larger than those above specified for larch, they shall be sound, and of the same dimensions and thickness, but these dimensions are only to include half an inch of sap.

When the sleepers are made from large timber, whether

oak, pitchpine, or teak, they shall be sound, free from sap or decay, and not shaken, to be squared up to the dimensions of nine inches by four and a half inches at the smallest part and nine feet long. All the wooden sleepers above described are to be subjected to Kyan's Patent Process.

To be Kyanized.

Laying and Ballasting the Permanent Sidings.

Sidings to be as drawn and directed.

The sidings are to be laid in such positions and in such lengths as may be directed by the engineer; they must be laid in the manner and form shown in the Drawing.

Rails to be Cut.

The contractor will be required to take up any part of the rails already laid down that may be found necessary to cut them into their proper lengths for the reception of the other iron work, to relay them, and fix all the necessary crossing plates, check rails, moveable points, or sliding rails, with the requisite machinery for moving them.

Contractor to find Ballast.

The whole must be made equally as firm and substantial as the other parts of the permanent way. The specification of the permanent ballasting, already described, must be considered applicable in all respects to the construction and ballasting of the sidings. The iron rails, chairs, keys, pins, points, crossings, switches, check rails, moveable points, or siding rails, and sleepers, being found by the company.

Time of Completion, Measurements, Payments, &c.

Time of Completion.

The contractor shall, on or before the ——————, complete the whole of the works herein specified, and such additional works as the engineer may direct to be executed, so as to render the line of railway along the whole distance in every respect fit for the safe and convenient transit of locomotive engines and other carriages.

Measurements.

All measurements of works shall be according to the actual dimensions, notwithstanding any general or local custom to the contrary.

Contractor to be present on works.

The contractor shall at all times be present on the works, or in his absence he shall provide a competent representative, fully authorized to act in his behalf in all matters relating to this contract.

Contractor

The contractor shall at all times, by day and by night,

to find labour and materials and to proceed as Engineer directs.

provide and use, at his own cost, all overlookers, labour, and materials of every description whatever that may be required for proceeding with and completing the works in a workmanlike manner, and shall proceed therein at the rate of progress that may be from time to time required by the engineer.

Descriptions and stipulations, though not repeated, to be understood.

It is to be understood, that though certain descriptions and stipulations are not repeated or implied in different parts of this specification, and in the contract to be entered into for the fulfilment of the same, it shall not be thence inferred that the remaining directions, descriptions, and stipulations, of which there shall be no repetition or amplification, are in anywise invalidated.

Contractor to furnish statements every two months.

The contractor shall at intervals of every two months furnish to the engineer a statement of all contract work done by him during that period; the value of which work shall be estimated according to the schedule of prices attached to the contract, and the amount of such account,

Payments to be made.

after being certified by the engineer, shall be paid to the contractor after deducting 10 per cent. off the amount; one half of such deducted sum for the preceding six months shall, at the discretion of the company, be paid over to the contractor at the termination of every interval of six months, if the contractor is proceeding with the works to the satisfaction of the engineer, and he shall certify to that effect, and the remaining half shall remain in the hands of the company during the progress and till the completion of the works, and for twelve months after their completion, when the amount, together with interest at the rate of 4 per cent., calculated from the period of completing the work, shall be paid to the contractor upon the certificate of the engineer of the whole of the work being in a satisfactory and proper state.

Advances to the Contractor.

In intervals between the periods of payments abovenamed, viz., every two months, the company will, if required, advance to the contractor payments on account of work and materials; the amount of such payments being dependent upon the certificate of the engineer.

Contractor to furnish statements previous to advances being made.

The contractor shall furnish to the engineer a statement of work done, and in respect of which he requires intermediate advances; but the certificate of the engineer shall only be for such amount as he may think proper to certify. And should the engineer be at any time dissatisfied with

If the works do not proceed satisfactorily, Engineer has power to procure any labour or assistance he may deem necessary, and charge cost to Contractor.

the nature or mode of proceeding in or at the rate of progress of the work, or any part thereof, he shall have full power to procure and make use of all labour and materials which he may deem necessary, deducting the cost of such labour and materials from the money that may be due or become due to the contractor. But it is hereby expressly declared, that the possession of this power by the engineer shall not in any degree relieve the contractor of his obligation to proceed in the execution of, and to complete the works with the required expedition. Should the contractor fail to proceed with the works in the manner and at the rate of progress required by the engineer, this contract shall be (at the option of the company but not otherwise) considered void, so far as relates to the work remaining to be done; and all sums of money that may be due to the contractor, together with the materials and implements in his possession, and all sums of money named as penalties for the non-fulfilment of the contract, shall be forfeited to the company, and the amount shall be considered as ascertained damages for breach of contract.

Alterations in additions to, or deductions from, any of the works.

It is to be distinctly understood that the engineer may at all times direct that there shall be made any alterations in, additions to, or deductions from, any of the works hereinbefore described or referred to; and which alterations in, additions to, or deductions from, the amount of work contracted for, shall be valued or estimated according to the schedule of prices, filled up by the contractor, and attached to his tender, and that the prices inserted in the schedule shall be considered including all labourage, materials, and all contingent expenses connected with the work to which such prices apply, and the contractor is required to fill up the whole of the schedule, whether the same appears applicable to the present contract or not.

Form of Tender.

I
of do hereby propose to make and complete the railway, with all the excavations, embankments, bridges, culverts, drains, fences, and other works connected therewith, including the laying and ballasting the permanent way throughout the entire length, from
to being a distance of and to keep the same in repair for one year after completion, and to find and provide all the requisite materials (except the iron rails, sleepers, chairs, and fastenings) according to the plans and specifications, and within the periods, and upon the terms and conditions mentioned and contained in the draft contract, exhibited to me, for the sum of .

And I have in the SCHEDULE hereto annexed, set forth the price of the different descriptions of work at which the aggregate amount of this tender is computed, and according to which the value of all additions to, or deductions from, the work specified, is to be estimated; and hereby undertake to execute a contract according to the draft before referred to within a fortnight from this date.

And I propose of
and of as sureties for the due performance of such contract.

Witness my hand this day of

Schedule referred to, containing a list of the prices at which the foregoing tender of ———— is computed, and according to which the value of all additions to, or deductions from, the work specified, is to be estimated.

	£	s.	d.
Average price of earthwork deposited in embankments, per cubic yard			
Earthwork deposited in embankments when the length of lead does not exceed one quarter of a mile, at per cubic yard			
Not exceeding half a mile . at per cubic yard			
Not exceeding three-quarters of a mile . do.			
Not exceeding one mile do.			
Not exceeding one mile and a quarter . do.			
Not exceeding one mile and a half . . do.			
Not exceeding one mile and three-quarters do.			
Not exceeding two miles . . . do.			
For every additional quarter of a mile . do.			

	£	s.	d.
Average price of earthwork in spoil banks per cub. yd.			
Earthwork in spoil bank excavated to the depth of 10 ft. below the surface of the ground, at per cubic yard			
Earthwork for every succeeding 10 ft. in depth, at per cubic yard			
Earthwork barrowed a distance not exceeding 25 yards, at per cubic yard			
Ditto for every additional 25 yards, ditto . .			
Soiling and sodding embankments, &c., including sowing with hay seeds, per sup. yard . . .			
Soiling and sodding cuttings, per do. . . .			
Dry pitching with sand stone, 9 in. thick, per do .			
Ashlar stone in foundations and in bond courses, pick dressed, and set in mortar, at per cubic yard			
Tool dressed and set in mortar. — Ashlar stone in walls from quarry, per cub. foot			
Tool dressed and set in mortar. — Do. „ —— do.			
Tool dressed and set in mortar. — Do. „ —— do.			
Tool dressed and set in mortar. — Do. „ —— do.			
Tool dressed and set in mortar. — Do. „ —— do.			
Tool dressed and set in mortar. — Do. „ —— do.			
Hammer dressed and laid in mortar. — Block in course stone work from quarry, per cub. yard			
Hammer dressed and laid in mortar. — Do. from do.			
Hammer dressed and laid in mortar. — Do. „ —— do.			
Hammer dressed and laid in mortar. — Do. „ —— do.			
Hammer dressed and laid in mortar. — Do. „ —— do.			
Hammer dressed and laid in mortar. — Do. „ —— do.			
Hammer dressed and laid in mortar. — Do. „ —— do.			
Coursed rubble backing with mortar, per cubic yard			
Random rubble backing do. do.			
Do. do. laid dry do.			
Well-burnt hard bricks, per thousand . . .			
Brickwork of do. set in mortar, at per cubic yard .			
Brickwork of blue Staffordshire or Bulkley mountain bricks, at per cubic yard			
Extra price of masonry in askew arches, at do. .			
Extra price of setting masonry or brickwork in Roman cement, at do.			
Do. of setting masonry or brickwork in water lime, at do.			
Concrete (6 of gravel to 1 of lime) with common lime, at do.			

	£	s.	d.
Concrete with water lime, at per cubic yard . .			
Puddle of clay, well tempered, at do. . . .			
Do. laid in 9 in. courses, and well punned, at do. .			
Common rubble walls for fences, including coping set in mortar, per Drawing, No.—, at per sup. yard			
Larch sleepers, Kyanized, at per sleeper . .			
Do. do. chaired and laid, at do. . .			
Oak sleepers do., at do.			
Do. do. chaired and laid, at do. . . .			
Common draining tiles laid in drains, at per thousand			
Bulkley mountain drain tiles, at do. . . .			
Post and rail fencing, including ditch and quicksets, at per lineal yard			
A field gate, with posts, &c., complete . . .			
Larch posts for fencing, 6 ft. 6 in. long, at per post			
Oak posts do. do. do.			
Larch rails do. 10 ft. 6 in. long, at per rail			
Post and rail fence for approaches to bridges, as per Drawing, per lineal yard, single fence . . .			
Laying and ballasting permanent way, including tile or brick drain, per lineal yard			
Laying permanent way, exclusive of ballast and drains, per lineal yard			
Ballasting only, per cubic yard			
Furnace slags, broken or spread, per ton . .			
Common cinders, do. do. . . .			
A paved crossing, complete, (see Fig.—, Drawing, No.—).			
Leading rails, and other materials, including loading and unloading, at per ton per mile . . .			
Pitch pine timber in balks, or large scantlings, delivered, at per cubic foot			
American red pine, do.			
Do. yellow pine, do.			
Baltic or Memel do.			
Subjecting timber to Kyan's patent process, do. .			
Cast-iron in girders or heavy work, fit and fixed, at per ton			
Do. in columns or piles, do. do. . .			
Do. small and ornamental, do. do. . .			
Wrought-iron, upwards of 7lbs. in a piece, such as plates, bolts, &c., fit and fixed, at per cwt. . .			

	£	s.	d.
Wrought-iron, less than 7 lbs., and more highly finished, fit and fixed, at per cwt. . . .			
Paving roads or streets with Welsh boulders, 6 inches thick, per sup. yard			
Ditto square sets, do. do. . .			
Metalling roads with hard stone, broken and spread, at per cubic yard			
According to general Drawing. — An occupation bridge over the railway			
Do. under do.			
Culverts of 6 ft. diam. without fronts, per cub. yd.			
Do. 5 do. do. do.			
Do. 4 do. do. do.			
Do. 3 do. do. do.			
Do. 2 do. do. do.			
Do. 1-6 do. do. do.			
Culvert fronts do.			
The price of sheet piling of Dantzic or Memel timber from 4 to 8 inches in thickness, shod with iron, hooped, and driven to any depth not exceeding 15 feet, and the tops cut off level and bolted to the walling, at per cubic foot			
Do. driven to a greater depth than 15 feet, but not exceeding 20 feet, at per cubic foot . . .			
Do. 25 feet, at per do. . . .			
The price of memel or beech sleepers ("Waling timber") bolted to the pile heads, complete, at do. .			
The price of larch, beech, or memel bearing piles, from 10 to 16 inches diameter, hooped, shod, and driven, with their tops cut off and levelled, ready to receive the planking—			
For any length not exceeding 15 ft., at per cubic foot			
Do. 20 ft., do.			
Do. 25 ft., do.			
The price of memel or beech planking, 2 to 4 inches thick, spiked to the pile heads, and prepared for the masonry, at per cubic foot			
The price of maintaining or keeping in good order the double line of permanent way and fences for the period of one year after the completion of the whole works, at per mile			

N.B. It is to be understood that only the exact quantity or net measurement of any material or work is to be taken in all cases, notwithstanding any custom to the contrary.

CHAPTER XIII.

COLONIAL SURVEYING.

THE first operations required in a perfectly new settlement, are, the division of the land upon which settlers are to be located into sections of such size as may be considered best adapted to their wants,—and the marking out the plan of the first town or towns, the sizes and positions of which will of course be regulated by local circumstances and advantages; whilst the first rural sections will naturally be required either in their immediate vicinity, or contiguous to the main lines of communication leading to the different portions of the province, whose local importance is the earliest developed.

In the case of a small settlement established upon the coast of any country for the immediate reception of settlers who require to be put in possession, directly upon their arrival, of a certain stipulated amount of land for agricultural or other purposes, the simplest form of survey must necessarily be adopted; that described in Capt. Dawson's Report upon the Survey of New Zealand for instance,—which consists simply in marking methodically upon the ground the angles of a continued series of square or rectangular figures, leaving even the roads which are intended to surround each block of sections, to be laid off at some future period,—would answer the purpose of putting impatient emigrants in possession of a homestead containing about the number of acres to which they might be entitled. But this system could not be carried out extensively with any degree of accuracy, even in a comparatively level country, and not at all in a mountainous or irregular one. In fact, it is not a survey; and though perhaps it may sometimes be necessary to adopt what Mr. F. Wakefield, in his recently-published pamphlet upon Colonial Surveying, terms this "make-shift process,"* the sooner a regular survey takes its place the better for the colony, even on the score of the ultimate saving that would be effected by getting rid of the necessity of incessant alterations and corrections; to say nothing of the amount

* For an explanation of the details of this species of surveying, see Mr. Kingston's Statements, page 33, Third Report of the South Australian Commissioners, 1838; and Captain Dawson's Report on the Survey of New Zealand, 1840.

of litigation laid up in store by persevering in a system necessarily entailing an incorrect division of property, upon which there is no check during the progress of the survey, and for which there is no remedy afterwards.

Excepting in some isolated instances such as described above, where every thing is required to give way to the imperative necessity of at once locating the first settlers upon land for which payment has been received, (for, by the present system of colonization, no land is alienated from the Crown otherwise than by purchase, the greater portion of the proceeds of the sale being devoted to the purpose of further emigration,) the first step to be undertaken at the commencement of the survey of a new country, is a careful and laborious exploration within the limits over which its operations are to extend; during which would be collected for subsequent use a vast amount of practical information as to the number and physical condition of the aboriginal natives (if any); the geological character of the soil; its resources of all kinds; sources and directions of rivers; inland lakes and springs; the probable sites of secondary towns; the most apparent, practicable, and necessary main lines of communication; prominent sites for trigonometrical stations, &c., &c. A sketch of the country examined, rough and inaccurate doubtless, but still sufficient for future guidance, is at the same time obtained; the positions of many of the most important points for reference being determined by astronomical observation, and the altitudes of some of them by the mountain-barometer or aneroid.

The next step should be, if this question has not been already determined by strongly-marked local advantages, or previous settlement, the position of the site of the first principal township; a nucleus being immediately required where fresh arrivals may be concentrated, prior to their dispersion over the country. The size* and figure of the town will of course vary according to circumstances; and the principal general requirements that should suggest themselves to any one charged with a decision of this nature, are,—facilities of drainage; plentiful supply of good water; easy access both to the interior of the country, and, if not situated on the coast, to the adjacent port; the apparent salubrity of the site; facility of procuring timber and other building materials, such as sand, lime,

* The size of the lots into which the township is to be divided may vary from a quarter of an acre to one acre; half an acre would be found generally sufficient. It is customary to give to the *first* purchasers of rural sections one town lot in addition for every such section, the remaining lots to be sold either by auction, or at some fixed price.

brick-earth, stone, &c.; security from predatory attacks, and vicinity to sufficient tracts of land suited to agricultural and pastoral purposes.

The site of the town, with its figure and extent, being decided upon after a careful investigation of the above and a variety of other minor considerations, the best main lines of road diverging from it in all the palpably-required directions should be marked out; and upon these main lines should abut the sections to be first laid out for selection. Errors of judgment will doubtless be subsequently found to have been made in the directions of some of these roads; but this is certainly productive of less injury to the colony than the plan of systematically marking out the land without providing for any *main lines of communication at all*, leaving them to be afterwards forced through private property under the authority of separate acts of the colonial legislature; a system entailing discontent, litigation, delay, and expense. The marked natural features of the ground, such as the lines of the coast, or the banks of lakes or rivers of sufficient importance to constitute the division of property, and the main lines of roads alluded to, will, where practicable, guide the disposition of the lines forming the boundaries of the sections to be now marked out. Where no such natural or artificial frontages exist, the best directions in which these rectangular figures can be laid out are perhaps those of the cardinal lines, excepting in cases where the nature, inclination, and general form of the ground evidently point out the advantage of a deviation from this rule.

The size of these sections is a question to be determined by that of the minimum average number of acres which it is supposed is best adapted to the *means* and *wants* of the settler; the latter being in a great measure regulated by the apparent capabilities of the soil. Land divided into very large farms is placed beyond the reach of settlers of moderate capital; and if subdivided into *very* small portions, the expense of the survey is enormously increased, and labourers are tempted to become at once proprietors of land, very much to their own real disadvantage, as well as that of the colony. In South Australia, 80 acres has been adopted as the average content. In parts of New Zealand* and elsewhere, 100 acres. In Canada†, generally more than double that quantity.

* In the Canterbury Settlement, on the Middle Island, New Zealand, 50 acres has been fixed as the minimum size; the maximum is unlimited. As in South Australia, no reservation is made of coal and other minerals, the purchaser being put in possession of all that is on and under the surface.

† The rude and inaccurate mode in which land has been marked out in Canada by

Whatever size may be determined upon, it is advisable to adhere to it as nearly as possible, in all general cases; though, where special application is made for rather larger blocks, there has been found no mischief in departing from the average size, provided this deviation is not so extreme as to prevent fair competition for any peculiarly valuable locality. In such cases, it is however always necessary to guard particularly against the monopoly of surface water within the area of the section, or of any extended valuable frontage; as well as against any impediment that might be placed in the way of forming roads through the property. Where the main lines of communication have not been previously laid out, it is requisite, especially in *large blocks* of land, to reserve to the government, at all events for a limited number of years, a right of forming such roads as are evidently for the public benefit, making of course compensation for any damage that may be thereby done, though this can generally be met by a previous allowance of a certain number of acres in excess of the proper content of the block*. Indeed, if proper precautions could be taken to prevent its being abused, it would be advisable to reserve this power of making such general roads as are clearly advantageous to the community, through all sections of land of whatever size; with the right of taking stone and timber for making and repairing these roads and the bridges erected along their line; though all such interference with private rights should as much as possible be obviated by previous careful examination of the country.

The rapid settlement of a newly-formed colony being an object always to be fostered, the sections marked out for sale should be so arranged as to conduce as much as possible to this desideratum; to attain which end, the surveys should, at all events at first, be kept well in advance of the demand for land, for the purpose of giving the most ample choice of selection to intended purchasers. By the opposite system of selling land in advance of the survey, an unfortunate emigrant not unfrequently finds the greater part of his section occupied by the bed of a salt lagoon or swamp, and experiences no slight dismay in discovering that he is not even in possession of the number of acres for which he has paid, and to which perhaps he has no access with any sort of wheeled vehicle, in consequence of the occupation roads being marked down upon the ground

the chain and compass, and the little value that has been set upon waste land which used to be alienated from the Crown in grants of extensive size, render the survey of that country not a fair point of comparison with that of more modern colonies.

* Two or three per cent. upon the average, is proved amply sufficient in small or moderate-sized sections. In very large blocks, one per cent. would perhaps be as much as could be required.

to correspond with straight lines previously drawn upon paper; so that they lead, without any controlling power in the surveyor to alter their course, up and down almost inaccessible ravines, or probably for several hundred yards at a stretch along the bed of a stream.

In marking out these sections, the following remarks* will direct attention to the different local peculiarities which require a deviation from established rules, and to the general system of conducting the work in the field; the mechanical practice of surveying being of course supposed to be already known.

Sections laid out with frontages upon main lines of road,—rivers,—or wherever increased value is thereby conferred upon the land, should have their frontage reduced to one-half, or even one-third of the depth of the section, so as to distribute this advantage among as many as can participate in it, without rendering the different sections too elongated in figure to be advantageously cultivated as a farm.

In addition to this contraction of frontage, easy access by roads must be provided from the country in the rear leading to this water, or main road; without which precaution the owners of the front lots would, by blocking up the land behind them, virtually obtain possession of it, for at least pastoral purposes, without payment. These roads should occur at intervals proportioned to their requirement, generally between every third or fourth section.

Every section should have an available road on one of the four sides forming its boundaries, by which the proprietor has access to the main lines of communication; its breadth may vary from half a chain to one chain, according to circumstances. In square or rectangular sections of 80 or 100 acres each, roads surrounding each block of six or eight sections have been found amply sufficient; but in a country at all broken or irregular, some of the roads so laid out would often be found quite impracticable; in such cases, it is necessary either to trace and mark on the ground along the ridges of the secondary features, or wherever the ground may offer fewest impediments, cross roads leading into the main lines, and to lay off the sections fronting upon them; or to make these by-roads run *through* the sections; which is to be avoided as much as possible on account of their cutting up small properties, and entailing a very considerable expense in the increased quantity of fencing required.

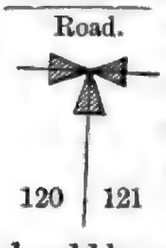
In parts of the country where water is scarce, the greatest care should be taken to prevent its monopoly by individuals. Springs

* Partly extracted from the instructions issued to surveyors employed in South Australia.

and permanent water-holes should in such localities be enclosed within a small block of land (one or two acres), and reserved for the use of the neighbouring flock-owners and the public generally; and practicable roads must be arranged leading to these reserves, without which, excellent and extensive tracts of land would often be comparatively valueless.

As it would evidently very much increase the cost of laying out sections having broken and irregular frontages, if they were required each to contain *exactly* the same number of acres; the nearest approximation that can be made to the established size by the judgment of the surveyor should be adopted, and the section afterwards sold according to the quantity of land it is found to measure.

For the purpose of giving to settlers seeking for land upon which to locate, every facility for acquiring information respecting its capabilities, and the positions of the different surveyed portions, the freest access to the statistical reports of the surveyors, and to the plans of the different districts deposited in the Survey Office, should be given. In addition to which, the sections themselves should be marked so distinctly upon the ground by short pickets, driven at intervals, regulated by the comparatively open and level character of the country, as to enable any person to follow up their boundary lines without difficulty. The *angular* pickets should be much larger, and squared at the head, on which the number of the section, and of all the contiguous sections, should be marked. Adjacent roads should also be designated by the letter R. Independent of the corners of sections being pointed out by these pickets, they should be deeply trenched with a small spade or pick, showing not only the angle formed by contiguous sections, but also the directions of their boundary lines.



Such marks remain easily recognised for years, and are not injured either by bush fires or by the constant passage of herds of cattle, by both of which means many of the wooden pickets are soon destroyed.

It has been generally considered expedient, that roads should be reserved, if not actually marked on the ground, (excepting in cases where they would interfere with the erection of wharves, mills, &c.,) along the banks of all navigable rivers, the borders of lakes, and along the lines of a coast. This regulation, if stringently applied, without reference to peculiar circumstances in different localities, would often be found oppressive and mischievous. Very frequently, roads laid out with judgment to the various points on the margins of these waters which are best adapted for the purposes of fisheries, watering flocks, establishment of ferries, building

or launching boats, &c., with a sufficient space reserved for the use of the public at these spots, would prove of more general utility.

As a general rule, as many sections as possible should be laid out in the same locality, if the land is of a nature to be soon brought into cultivation. Whilst greater choice of selection is thus given, the comparative cost per acre of the survey is diminished; of course, this remark applies only to situations the rapid settlement of which is anticipated.

In marking the boundaries of sections on the ground, all natural features crossed by the chain should be invariably noted in the Field Book, on the outlines plotted from which are drawn the general character of the contours of the hills, the different lines proposed for roads, directions of native paths, wells, springs, and every other object tending to mark the nature and resources of the country. Copies of these plans* should always be transmitted to the principal Survey Office, accompanied by a rough diagram, showing for future reference, the construction lines of the work, and the contents and length of the sides of all sections, also the measure of the angles, when not right angles; and by an explanatory report, describing the nature of the soil, description of timber, &c., upon each section, and the facilities for making and repairing roads and bridges, and peculiar geological formations of the different districts. A collection of botanical and mineralogical specimens from all parts of the province will also contribute materially to the early development of its natural resources; and surveyors should not be deterred from giving their attention to this subject by ignorance of these sciences, as the specimens can be afterwards weeded and arranged, and afford invaluable statistical information.

At the head Survey Office, a meteorological register is of course supposed to be kept. It is also very desirable that each of the surveyors employed in any large district should be furnished with a good thermometer, rain-guage, and a mountain-barometer, or aneroid, for the purpose of registering daily observations to be forwarded periodically to the general office for comparison with those obtained from different parts of the province, between which the difference of peculiarities of climate will be thus arrived at.

Surveyors working on a line of coast should be particular in noting all phenomena connected with the rise and fall of the tides; and obtain soundings, laid down with reference to established and easily-recognised marks on shore, of all creeks and harbours, when-

* Two inches to one mile is found a very convenient scale for plans of these sections, intended for the information of the public.

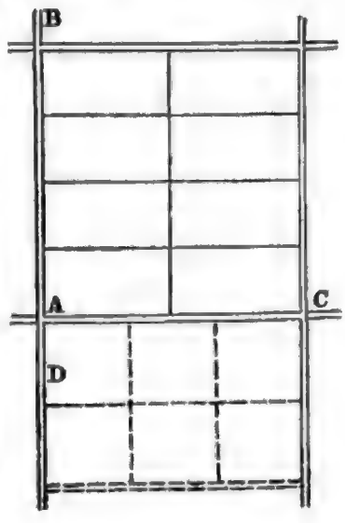
ever this may be in their power. The depths and velocities of all rivers should also be noted at different points in their course, as well as the periods of floods, and their observed influence upon the volume of water in the river.

In laying out sections up narrow rocky ravines, or in situations where creeks or any other natural features present obstacles to the continuance of the methodical rectangular form adopted as the standard figure, a deviation from this form becomes of course necessary, and the contents of some of the sections thus often unavoidably differ from the established average. Care should however be taken in such cases, to make the outline of these irregular figures as simple as the ground will admit of, both on account of the additional trouble and time lost in their survey, and the increased cost of subsequent fencing by the purchaser.

Attention has already been drawn in page 428 to the necessity of guarding against the monopoly of road or water frontage. The same sort of precaution is also required in marking out land in rich narrow valleys, or in spots valuable on account of minerals. As a general rule, from which no deviation whatever should be allowed, it may be laid down that no section should ever be permitted to enclose an undue proportion of land, unusually valuable from whatever cause, by *extending its length in the direction in which that valuable portion of land runs;* whether it be a rich agricultural valley, a mineral lode, a stream, or water-course.

As regards the actual marking out of the sections upon the ground, when the figure is of a square or rectangular form, the process is a very simple one; whether the true meridian, or the direct line of some main road, or a line forming any angle with the meridian that may be found better adapted to the local peculiarities of the district, be adopted as the guiding line of direction.

A spot being fixed upon for the starting point, represented by A in the accompanying figure*, the normal line A B is carefully marked out by a good theodolite in the required direction; if intended to correspond, or to form any fixed angle, with the meridian, this must be previously determined by one of the methods usually practised. The right angle B A C is then set off, which angle should be observed on both sides of A B (produced on purpose to D), and the chain measurement along these lines A B



* This figure represents rectangular sections of 80 acres, as laid out in South Australia,

and A C, and afterwards along the parallels to A C, may, if two parties are employed together, which can generally be managed under the charge of one efficient surveyor with an intelligent assistant, be carried on simultaneously, the points of junction at the angles of the blocks forming in some measure checks upon the accuracy of the work as it proceeds. The size of these sections, and the intervals between the parallel sectional roads, will depend of course upon local regulations. The operation would evidently be simplified by running all the measured lines in the middle of these roads, leaving half their breadth to be afterwards set off on each side by the proprietors of the land, but the palpable objections to this are too serious to be compensated by the trifling saving thereby effected. In fact, the real boundaries of *no one section* are by this plan marked on the ground by the surveyor; and constant disputes and encroachments would be the consequence of adopting it.

It must be obvious to every practical surveyor, that it would be impossible for him to continue this mechanical system of marking a series of rectangular figures on the ground to any great extent, without being liable to constantly-increasing errors, which could not be guarded against by any degree of care in the operation, and of the amount of which he could never be aware, without establishing some check altogether independent of the chain measurement of the sections themselves: this is only to be accomplished by combining with it a triangulation of the country, more or less accurate, according to the nature of the survey. Whilst, then, this methodical division of the land is in progress, it is advisable, if any thing like accuracy is required, and if the detached portions of settled country are to be laid down upon a general map, that the sites of the trigonometrical stations should be decided upon, and the stations themselves (however roughly they may be constructed) erected, in order that they may throughout be made use of as guides and checks upon the measurements. The triangulation indeed would be found of the greatest service, if carried on rather in advance of the detail, as in the survey of old countries. Any great accumulation of error could be then easily guarded against, by the angles observed at different parts of the chain survey, subtended by three or more of the trigonometrical stations; and in very many instances these stations could be actually measured up to, which should be done wherever practicable; by which means

the length of which bore to their breadth the proportion of 2 to 1—occupation roads one mile apart, enclosing eight sections. They were, however, frequently laid out square, according to the nature of the ground.

the marking out of the sections answers the same purpose that is obtained in ordinary surveys by the measurement of check lines, and traversing along the roads, by which the interior detail is mostly filled in. Angles of depression and elevation should also be taken to these trigonometrical points (whose altitudes are all obtained by the triangulation), from various parts of the chain survey, the heights of which positions, above the level of the sea, are thus obtained with tolerable accuracy.

As to the mode of conducting this triangulation, all necessary instructions have already been previously given. The degree of accuracy with which the base is measured, and the angles observed, will depend evidently upon various contingencies; for instance—the extent over which the triangulation is to be carried; the time and expense that can be bestowed upon it; the degree of minutiæ required in the maps, &c., &c. On the survey of South Australia the base was measured upon a nearly level plain very little elevated above the sea, with a standard chain, the operation being repeated several times, to obtain a more correct mean value: the angles were observed with a very excellent 7-inch theodolite; and the result was found sufficiently accurate for the purpose of connecting all the detached blocks of surveyed land, and laying down the work to the scale of 2 inches to 1 mile.

In addition to the above use of the triangulation, it is found, in the survey of a wild country, peculiarly serviceable in enabling the Government to define, with the aid of marked natural features, the boundaries of the extensive tracts of land leased to different individuals for pasturage, until, with the increase of population and civilization, more convenient and better-defined demarcations are substituted. Some of the principal natural landmarks of a country also, such as chains of mountains and rivers, traverse the wildest parts of the land, where chain surveying would never penetrate. Many of these landmarks are made the boundaries of counties, and other internal territorial divisions; and their positions in different parts of their course are often only to be determined by reference to the trigonometrical stations, which likewise serve as guides for ascertaining and laying down upon paper the directions of roads through extensive, barren, and uninhabited tracts of country.

Most of the foregoing remarks have been made under the supposition that a number of detached surveying parties are distributed over different parts of the country, all working under the directions of, and reporting to, a central Survey Establishment. As the population becomes distributed over a wider extent, and

applications are constantly made for the survey of small, irregular blocks of land to complete and consolidate properties, some alterations will be required in the method of carrying on the measurement of land, to meet these new demands*. It could evidently be only by an increased expenditure of time and money that surveying parties could be kept constantly moving from one distant spot to another, to lay out perhaps, only a very limited number of acres at each; and the division of the country into *Districts*, for the purposes of the survey, becomes almost imperative. Copies of the plans of sections open for selection, and other information of a similar character, would be thus placed more within reach of distant settlers, and their wants could more readily and rapidly be met without augmented expense.

Portions of the work might also at this advanced stage of progress be filled in by contract, subject to careful and rigid examination; the triangulation, and the previous chain measurement connected with it, affording sufficient checks for this purpose; without which, surveying by contract should be most carefully avoided, especially in new communities where but little competition can be expected, and where it would be unreasonable to expect to find competent surveyors distributed over the remote parts of the colony.

The rate of progress and cost per acre of a sectional survey, such as has been described, must vary considerably, according to the nature of the country, the prices of labour and provisions, and the minuteness of the divisions. If the size of the sections is small, 80 or 100 acres for instance, the number of lineal miles to be measured is of course very much greater in proportion than would be the case with blocks of a larger area, and the progress must bear an inverse ratio to the increased expense. The facility of transport is another item that materially influences both these questions, as also the system of marking out patches of land in whatever locality they may be applied for, instead of carrying the survey regularly forward, embracing all the available land in its progress.

The expense of the surveys in all new colonies is now defrayed out of the proceeds of the sales of land; and proof of the recognition of the advantages of the accurate delineation of the boundaries

* These subsequent wants and demands do not affect the first stage of the survey in a new country; it is only as it becomes gradually settled that they are felt. The first survey evidently cannot be a *complete* one, unless it could embrace every acre of land that might by possibility be required; it is constantly demanding *extension* in every direction, therefore the more imperatively necessary it is, that the first land surveyed and laid down on the maps should be based upon a triangulation sufficiently accurate to allow of this extension, without the certainty of accumulating error.

of property, features of the ground, and main lines of roads, &c., is given by the system adopted by the New Zealand Association, in the establishment of the "Canterbury Settlement," of charging for all land the uniform price of £3 per acre*, (instead of the £1 fixed as the lowest upset price in the other Australian colonies, where the plan of selling land by auction is in force), to provide funds for a superior nature of survey, and a variety of works of a public character; the proportions being 10*s.* per acre as the price of waste land; 10*s.* per acre for the cost of the surveys, formation of roads, and other miscellaneous expenditure; 20*s.* per acre to be devoted to the purposes of emigration; and another 20*s.* per acre to ecclesiastical and educational purposes.

The boundaries of what in the Australian colonies are termed "*Runs*," for depasturing sheep and cattle, are not generally marked out during the survey, but are described by reference to the trigonometrical stations, and other known fixed points; the approximate distances and bearings of the lines being stated. As portions of this land are at all times liable to be purchased by individuals after a due stipulated notice to the occupier of the run, who pays yearly a trifling sum for his licence, it would of course be a waste of labour to mark out such temporary divisions; but the settlers themselves very frequently define their respective limits, either by blazing the trees in a wooded country, or by running a plough line across it in an open one.

As regards the interior division of a colony into counties, &c., the following general regulations, established many years since, are still in use:—

Counties are to contain, as nearly as may be, 40 miles square; hundreds, 100 square miles; and parishes, 25 square miles.

Natural divisions, such as rivers, streams, highlands, &c., to constitute as much as possible these boundaries; and, for the purpose of obtaining a well-defined natural boundary, a smaller or greater quantity than the above averages is permitted; but not to exceed or fall short of such established areas by more than one-third of each.

Reserves are allowed to be made for all necessary public roads and other internal communications, either by land or water; also

* Formerly land used to be sold in South Australia at the uniform fixed price of 1*l.* per acre. The system of selling by auction was introduced by the Australian Waste Land's Act in the year 1843. There are various opinions as to the comparative merits of these opposite systems, the first of which was introduced by Mr. E. G. Wakefield; and its advantages are strongly set forth in the pamphlet upon Colonial Surveying, recently published by his brother, Mr F. Wakefield.

for the sites of towns, villages, school-houses, churches, and other purposes of public utility and convenience.

When the division between Provinces or Counties, or other lines of territorial demarcation, is represented, either altogether or in part, by a meridian line; or a line having any fixed angle with the meridian; or by a portion of the arc of a parallel (as is the case in many of the Australian provinces), it is of course necessary to be able to determine and mark upon the ground with accuracy such meridian or parallel. Most useful practical information upon this subject will be found in the narrative of the survey and marking of the boundary between the British possessions in North America and the United States of America, in 1842, published by Major Robinson, Royal Engineers, in the second and third volumes of the "Corps Papers."

Operations of this nature, if conducted with the very great care and precision that were bestowed upon the boundary alluded to, involve the perfect knowledge of the manner of using and adjusting the transit, and altitude and azimuth instruments; and also the management of chronometers. The boundary line between South Australia and what now constitutes the province of Victoria, (the 141st degree of east longitude) was however determined (and since marked on the ground for a considerable distance,) under the New South Wales Government, by one of their surveyors*, with only a sextant, a pocket chronometer, and a small 3½-inch theodolite; but though the work was performed with the greatest care and attention, and with probably as great a degree of accuracy as could be obtained with these imperfect instruments, the result can of course only be looked upon as an approximation far too vague for the determination of a division of importance. The North American boundary, on the other hand, may perhaps have been defined with more precision than was absolutely necessary in a line of demarcation running for its whole length through a wild uncleared country.

Having now gone through the method of dividing the land into minute sections for occupation, and its further division for territorial purposes; we will conclude with a short reference to the objects to be held in view in conducting exploring expeditions beyond the bounds of the settled districts, for the purpose of adding to the geographical knowledge of the country and developing its resources; which objects are very similar in character to those already alluded to, when treating of the preliminary operations of a survey in a newly-formed colony.

* Mr. Tyers.

The nature of the country to be traversed will, as far as this is known, indicate the method of travelling that must of necessity be adopted. Extensive inland water communication, as in the Canadas, points to the canoe as the readiest mode of transport; comparatively open and generally grassy land, as in Australia and Southern Africa, requires the use of horses and oxen; whilst in many other countries the thick underwood can, in parts, be traversed only on foot, and barren deserts by the aid of camels. These different modes of locomotion evidently all require different preliminary arrangements. The objects in view, however, are much the same in all cases*; viz., a knowledge of the climate, soil, native population, geological formation, botanical character, of the country, and its resources of all kinds; as well as the delineation (as perfect as the time and means that are available will admit) of the natural features of the ground.

All points known as portions of the settled country being soon left behind, the explorer has to trust to his own judgment as to the best directions in which to conduct his party; to his own energy in overcoming the natural obstacles that he will be certain to encounter; and his own practical skill in fixing at proper intervals his different positions by means of astronomical observations, and mastering rapidly the general massive features of the ground for the purpose of making a rough sketch of the country passed over, showing more particularly the directions of the principal ranges of hills, and of rivers, and water-courses.

In a large party these labours may often be subdivided advantageously; but the leader must remember that the *entire responsibility* still rests with him; and if he does not actually participate in every portion of the work, he must nevertheless exert a general influence over the whole.

As regards the fixing, with as much accuracy as may be attainable, the various positions of encampments, the directions and sources of rivers, and all marked prominent features; much assistance is to be obtained by carrying on, as far as it can be done, a species of rough triangulation (with a sextant or other portable instrument), from the extreme trigonometrical stations, or any prominent landmarks the positions of which are known and represented on the plans. This may however very soon become impracticable from the nature of the country or other causes, and the traveller then finds himself much in the same predicament as at sea, having little beyond his dead-reckoning to trust to for the de-

* Expeditions for one single definite object, such as tracing the sources of a river, &c., are not intended to be here referred to.

lineation on paper of his day's work. In this position he must look to the heavens for his guide: and hence the necessity for his becoming himself, or having with him, a good and rapid observer.

At sea, the latitude is always obtained at noon by a meridian altitude of the sun (when visible); "*sights*," as they term observations of single altitude for time, having been taken three or four hours before. The latitude obtained at noon is then reduced by dead-reckoning to what it would have been at the time and place of the morning observation, (using the traverse table;) and with this deduced latitude the hour angle is computed, and the equation of time, *plus* or *minus*, applied for the mean local time, which, when compared with the Greenwich time, shown by the chronometer, (allowing for its rate and error), gives the longitude east or west of Greenwich *at the time of the morning observation.*

By applying, by dead-reckoning, the change in longitude between that time and noon, the longitude of the ship at noon is obtained,—the latitude has already been found by direct observation,—and the two determinations afford the means of recording upon the chart the position of the ship at *noon* on that day.

Somewhat similar to the above proceeding, must be that of the explorer in a wild unknown tract of country. He would not probably find it convenient always to obtain his latitude at noon; but he can generally do so, and more correctly, at night, by the meridian altitude of one or more of the stars of the first or second magnitude, whose right ascension and declination are given in the Nautical Almanac. His local time can, immediately before or after, be ascertained by a single altitude of any other star out of the meridian (the nearer to the prime vertical the better); and if he carries a pocket chronometer upon which any dependance can be placed, he has thus the means, by comparison with his local time, of obtaining his approximate longitude, and of laying down his position upon paper.

In travelling, the rate of the chronometer will probably be found to vary; but as frequent halts of two or three days are likely to occur, these opportunities should never be lost of ascertaining its change of rate. The longitude should also be obtained occasionally by lunar observations on both sides of the meridian; or by some of the other methods given in the works on Practical Astronomy.

The results deduced from such observations must not be relied upon within ten or twelve miles, but a careful observer should rarely exceed these limits; and his latitude ought always to be within half a mile, or under the most unfavourable circumstances, one mile, of the truth.

With these all-important data, enabling him to fix with approximate accuracy point after point* in his onward course, the explorer can have no difficulty in interpolating by angles, taken with a sextant or with an azimuth compass, all strongly-marked prominent features, or in laying down his route upon paper correctly enough for the purposes of identifying particular spots, and giving a faithful general representation of the features of the ground he has travelled over. The value of this sketch will be much enhanced by its having recorded on it, as nearly as they can be ascertained by the mountain barometer or aneroid, or by the temperature at which water is found to boil, the altitudes of the most important positions, as the summits of hills, the levels of plains, and sources of springs and rivers.

Daily meteorological observations, even of the most simple character; such as merely recording the readings of the thermometer and barometer at stated times, will also prove of essential service as illustrative of the climate; and these will be of additional value if accompanied by a record of the quantity of rain fallen on different days, should any portion of the party be stationary for sufficient length of time at any one spot, to make these observations. If not provided with a rain guage of a better description, a tin pipe with a large funnel, the area of the top of which bears a certain proportion to that of the tube, will answer perfectly to measure the quantity of water fallen. A light graduated wooden rod is fixed in a cork float, and indicates, above the level of the top of the funnel, the number of inches; the graduations of the rod of course being proportioned to the ratio between the areas of the surface of the funnel and that of the tube. Thus, if the proportion is 10 to 1, the measuring rod will be lifted 10 inches for every inch of rain.



* The distance between positions, the latitudes and longitudes of which have been determined, can be easily obtained by calculation; by which means they can be laid down with more accuracy, provided the extent of ground travelled over is not very great.

CHAPTER XIV.

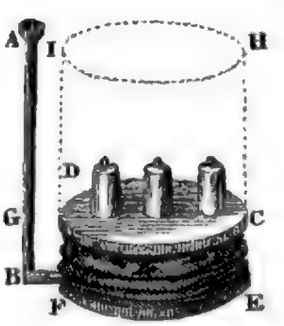
HYDRAULICS,

IN CONNECTION WITH DRAINAGE, SEWERAGE, AND WATER SUPPLY.

THE first principle to be understood and to be ever borne in mind in hydraulic or hydrostatical calculations is that, unlike "solids," whose pressure is always *downwards* in the direction of gravity, "fluids" press *equally* in every possible direction, even *upwards;* consequently, if any portion of the upper part of a fluid be replaced by a part of the vessel containing it, the pressure against this from below will be the same which before supported the weight of the fluid removed, and every part remaining in equilibrium, the pressure on the bottom of the vessel will be the same as it would be if the vessel were a cylinder or a prism.

It is usual to calculate the pressure of fluids with reference to a square inch of the surface of the vessels containing them, or in contact with them; but, whatever may be the modicum of surface assumed, the pressure is equal to the weight of a column of the fluid whose base is equal to that modicum, and whose height is equal to its depth below the apex or top surface of the fluid.

Hence what is called "head," or the height of a fluid, is of the utmost possible importance, for, if there is but a sufficiency of head, a column of fluid of the smallest possible diameter, may be made to balance another quantity, or any weight as large as you please. This principle has been denominated the Hydrostatic Paradox, but as I believe, inappropriately, for I do not think there is anything paradoxical about it.



The figure represents a machine called the hydrostatic bellows, which is sometimes used to illustrate this principle. The bellows consists of two thick boards C D and E F, connected with leather, or other expansive material; a pipe of very small diameter, but of considerable length, communicates with the bellows a little above the point F. Now if water be allowed to run into the pipe at the point A—either by connecting it with a cistern, or, if the experiment be made in a room, with an ordinary water-can

suspended from the ceiling, it will fall down the pipe into the bellows, and will gradually separate the bellows boards raising and sustaining a weight that may be placed thereon, bearing the same proportion to the weight of water in the pipe above the level of D C as the area of the bellows board bears to the sectional area of the pipe, and this is evident from what has been said as to the equilibrium of the pressure of fluids; since whatever may be the downward pressure of water in the pipe, there is an upward pressure in the bellows upon every fractional part of its surface that corresponds with the sectional area of the pipe, equal to the weight of a column of water, whose diameter is the diameter of the pipe, and whose height is the height of the pipe diminished by the height of the water in the bellows.

It is a well known principle of hydraulic science that "*water will always find its level,*" hence water poured into a bent tube at one end will rise to the same level at the other end before it becomes quiescent: thus are we able to supply water to the inhabitants of a town from a reservoir on a hill, to any height in their dwellings that shall not exceed the level of the water in the reservoir, notwithstanding the pipes conveying the water may in their passage from the reservoir to the town, have passed through valleys and hollows of great depth.

Fluids of different specific gravities that do not mix will counterbalance each other in a bent tube when their heights above the surface of junction, are inversely as their specific gravities.

In common-place matters of business, the most useful, although perhaps, the most difficult, and until lately the least advanced branch of hydraulic science, is that which relates to the motion of fluids, and the part which friction plays upon them in their passage through confined channels and (especially at the present day) conduit pipes.

There is little doubt that some simple fixed mathematical law, prevails throughout all nature's works, and that such is the case with regard to fluids in motion has been demonstrated by frequent experiments. Perhaps the most able exposition of this law in hydraulics, is to be found in a work called "Practical and Experimental Researches in Hydraulics," by R. A. Peacocke, C.E. extracted from Weale's *Quarterly Papers on Engineering.*

I have already explained that the pressure of fluids is alike in all directions, consequently in considering the question of

discharge of water through pipes, we must make no difference between a pipe laid *level* but having a constant head behind it, and another pipe whose gradual fall amounts in the aggregate to that constant head. As an illustration, let B C, fig. 179, be a constant head of water, and A B a horizontal pipe; then the same quantity of water will be discharged at the point A, in the same time, by the horizontal pipe, as would be discharged by a pipe laid hypothenusally, as in fig. 180, provided that the top surface of the water be kept at the same height at C, above the point A in each case, and that the point A, is at the same horizontal distance from C.

If any be inclined to doubt the correctness of this principle, they may find a strong confirmation of it, in the results of some very valuable experiments communicated to the Institution of Civil Engineers by Mr. W. A. Provis, M.I.C.E., and contained in the "Account of the Transactions of that Society," vol. ii, p. 201.

But for the existence of friction, water would fall a given height in the same space of time whether the points of supply and discharge were situated vertically above each other or whether a considerable horizontal space intervened, but inasmuch as the discharge of water must be vertical unless conducted otherwise by some artificial medium, the resistance offered by friction is greater or less according to the rate of inclination at which the conducting medium is brought in contact with the water.

At a time then when sanitary questions are occupying a very great share of public attention, and every town in the kingdom is establishing its waterworks and carrying out works of drainage, it becomes more than ever important that the quantity of water discharged from pipes under all the varied circumstances of greater or less diameter, head and pressure, should be distinctly understood.

Among the several rules for calculating the discharge of water through pipes, may be mentioned that of the Chevalier Dubuat, in his *Principes d'Hydraulique*, an abridged account of which is given by Professor Robison in his article on rivers and water works in the *Encyclopædia Britannica;* the formula of M. Eytelwein, a German mathematician, who devoted much time to enquiries of this nature, and published at Berlin in 1801 a valuable compendium of hydraulics, entitled *Handbuch der Mechanik und der Hydraulik.* The formula and table of Mr.

Smeaton; the formula of M. Prony; Dr. Young's deductions from experiments and comparisons; the conclusions of M. Genieys contained in a quarto work, published in Paris in 1829, entitled *Essai sur les Moyens de conduire, d'élever et de distribuer les Eaux, par M. Genieys, Ingénieur au Corps Royal des Ponts et Chaussées, attaché au service de la Distribution des Eaux dans Paris;* the experiments of the Abbé Bossuts; and the experiments of M. Couplet; the results of the very valuable experiments by Mr. Provis, M.I.C.E.; the researches of Mr. Peacocke, C.E.; and the formula of Mr. Hawkesley.

The rules and formula of most of the early authors are expressed in such different terms, and produce such conflicting results, that they are of little value for the practical requirements of the present day.

Two or three years ago, I turned my attention to this subject; collected and investigated the several formula, in connection with the recorded experiments, and tabulated the results. A second and very extended edition* of these Tables has been for several months in progress, and will probably be ready for the press by the time this work leaves the hands of the printer.

* *Synopsis of the Second Edition of* "RYDE'S *Hydraulic Tables.*"

Table 1. Relative inclinations, especially applicable to Table 8.
„ 2. Relative inclinations, especially applicable to Table 10.
„ 3. Relative values of the properties of a circle, (very complete).
„ 4. Square roots of numbers, from 1 to 1000.
„ 5. Cube roots of numbers, from 1 to 1000.
„ 6. Logarithms of numbers.
„ 7. Hyperbolic logarithms.
„ 8. Discharge and velocity of water and sewage passing through pipes.
„ 9. Loss of head, occasioned by the friction of bends and angles, whether in pipes, rivers, canals, or other arterial cuts.
„ 10. The mean velocity of water flowing through rivers, canals, drains, or other arterial cuts, according to depth and fall.
„ 11. Surface, mean and bottom velocities of rivers.
„ 12. Approximate swell occasioned by the piers of a bridge or other contraction of the water way.
„ 13. Weight and thickness of cast iron pipes, required to sustain the pressure of different heads.
„ 14. Velocity of water discharged from reservoirs, sluices, bridges, and vertical pipes.
„ 15. Discharge of weirs and overfalls.
„ 16. Quantity of water in cubic feet due to rain-fall, on any number of acres.
„ 17. Relative quantities of rain-fall for different measures of time.

INCLINATION 1 IN 15.

DIAMETER OF PIPE.	DISCHARGE PER MINUTE.		VELOCITY PER MINUTE.
Inches.	Gallons.	Feet.	Feet.
1	8.	1.2	228.
1½	21.	3.4	278.5
2	43.	6.9	318.
2½	76.	12.2	358.
3	**120.**	**19.2**	**392.5**
4	245.	39.3	451.5
5	429.	68.9	505.5
6	**677.**	**108.7**	**554.**
7	996.	159.8	598.
8	1390.	223.2	639.5
9	**1867.**	**299.6**	**678.5**
10	2429.	389.9	715.
11	3082.	494.8	750.
12	**3832.**	**615.1**	**783.**
13	4678.	750.8	814.5
14	5626.	903.	845.
15	**6694.**	**1075.**	**875.5**
16	7862.	1262.	904.
17	9143.	1468.	931.
18	**10560.**	**1695.**	**959.**

The Tables (of which a specimen is given on page 444) show the discharge and velocity of water and sewage flowing through pipes of any diameter from 1 inch to 18 inches, and at any rate of inclination from 1 in 10 to 1 in 1000. They are equally applicable to the passage of sewage through drains, or pure water through water pipes; because in the case of the former, every additional junction throughout the entire course of the drain increases the pressure, and consequently the velocity; while in the case of the latter, the effect produced by each branch of a water service, increases the friction, and therefore diminishes the flow.

The arrangement of the Tables is so simple as to need but little explanation. If it be required to ascertain the size of pipe that will discharge a certain amount of sewage, or supply a given amount of water at a known fall, it is simply to turn to the page headed with the given rate of inclination, and take out the diameter, which stands opposite the number most nearly representing the given discharge.

It is not at all times understood why a small pipe drain shall effectually perform the functions for which it is intended, when a larger pipe has been previously deputed to the same task and failed. In a large drain the run of water is spread over a broad surface in a thin sheet, by which means the friction is considerably increased, indeed exerted to the utmost—the flow is greatly retarded thereby, and the heavier matters at first held in suspension are by the natural law of gravity eventually deposited. In the small pipe on the contrary the water is concentrated, friction is reduced—the flow is greatly accelerated in consequence and all matters are held in suspension and carried away. Thus if anything not intended to be received by the drain, should accidentally find its way thither, the shallow stream with little velocity or power to float a heavy body, and having moreover plenty of room to pass it by, adopts the opportunity afforded by the unnecessary size of the large drain, and leaves the foreign substance where it found it; there to accumulate other matters and become the nucleus to what may eventually choke the drain. In the small drain on the contrary, if a foreign substance enter, or an impediment of any kind is presented to the ready flow of the water—the hydraulic pressure is immediately increased and brought to bear upon the resisting medium, which cannot long resist, and it is carried headlong down the channel by means of the superior force itself has created, and never stops again until it is precipitated at the outlet of the sewer. Fig. 181 represents a 15-inch drain in which the height of water is supposed to be as there shown—and

the impeding substance is also drawn. But if this were a 4-inch pipe as shown in fig. 182, the same quantity of water would have assumed a very different relation towards the impediment, and its power to remove it will be readily comprehended on examination of the sketch.

Having referred to my tables as simple expositors of the capacities of pipes for the purposes of drainage, sewerage, and water supply, according to the inclination at which they are laid, I now propose to treat briefly the practical operation of draining a town and supplying it with pure water.

Undoubtedly the first desideratum in considering the question, is to secure the best possible outfall for the drainage, sufficiently removed from the town to prevent inconvenience or nuisance from noxious effluvia, and yet in a position if possible to enable the sewage to be intercepted and used as an agricultural manure, if the agriculturists in the neighbourhood are willing and can make it answer their purpose to co-operate with the town's people for its purchase.

Upon this question of application of sewage to agricultural purposes, much diversity of opinion exists; personally I am inclined to believe, that if the landowners and farmers in the vicinity of every town in which proper works of drainage have been executed be invited to make propositions for the right of using the sewage, it will be found that in most cases, after a sufficient trial has been allowed to enable them to discover the proper mode of using it, and most economical manner of applying it, that a revenue of 5*s.* per annum for each inhabitant, at the very minimum, may be realised from that which is at present not only thrown away, but what is far worse, is suffered to injure to a large and unknown extent the health and physical condition of our town populations.

Having determined upon the outfall, the next question is to lay out judiciously the main sewers, so that each street may have at least one drain, laid at such a depth as shall drain the foundations of the houses; into which surface grates, at properly regulated intervals, will open by means of trapped side drains, as well as the secondary drains from houses, courts, &c.

There are few towns, excepting only the very largest, that may not be efficiently drained by means of glazed stone ware pipes, without resorting to more expensive, and less serviceable sewers.

The main drains should be laid out, so as to reach by as direct a course as possible the point of outfall, for to decrease the length of a drain is the same as to increase the fall; they should also be

as free as possible of sharp angles and bends, and should maintain throughout, as nearly as can be accomplished, a regular rate of inclination.

The greatest internal diameter of drain pipe recommended to be used, is 15 inches; beyond this size they are rarely true in form, and are very difficult to lay down properly. I have had laid down under my supervision pipes 18 inches in diameter, but the work is not nearly so satisfactory as the smaller sizes, although it has now worked very efficiently for more than four years. In all future operations, I shall consider the propriety of making two drains in all cases in which a 15-inch pipe will not meet the requirements.

In digressing a little from my subject to describe the kind of map upon which the drains must be marked out, I feel I cannot do better than refer to the valuable suggestions of the General Board of Health on this particular question, bearing as they do the high stamp of official authority, and being exempt, as they necessarily must be, from every imputation of interested motives, which generally attaches to a professional man, when suggesting works tending to benefit himself or his order.

Having issued to engineers and surveyors specimen plans on a prescribed scale showing every possible detail relating to sewerage, drainage, and water supply, the General Board in their Minutes of the 26th July 1850, remark:—

"There appears to be generally an imperfect acquaintance with the actual necessity and value of proper surveys upon which required works of improvement have to be founded. It seems to be very frequently supposed that if any sort of plan exists of a town or neighbourhood it will answer the purpose and that further expenditure upon the survey of a district would be both unnecessary and wasteful. It may be safely asserted however that so far from these surveys being either valueless or costly, that works of sanitary improvement cannot be satisfactorily or economically carried out without trustworthy plans prepared from these surveys.

"In respect to the principal works of improvement, namely, drainage works, one chief source of waste from inefficiency, arising from the want of a complete system of levels, has been the laying down of lines of sewers at insufficient or wrong inclinations, which combined with errors as to forms and modes of construction have made drains and sewers, instead of serving for the rapid discharge of all matters intended to be conveyed away, mere reservoirs of deposit, increasing the amount of noxious evaporating surface beneath the site of the town.

"It has been moreover the usual custom hitherto to lay out the lines of drainage upon street plans merely, without regard to the disposition of properties, or other facilities for the work which would present themselves upon good and complete plans. Thus a line of sewer is necessarily marked down every street into which the drainage of each house has to be separately led.

"It has appeared also upon recent investigations, that there has been great extravagance, not only from this want of complete general surveys as the founda-

tion of drainage works, but from the insufficiency of any district surveys for the laying out of the main works, those of house drainage.

"Various comparisons have been recently made of different districts of the metropolis, with the view of exhibiting the immense economy of the proposed detailed plans on a large scale as affording the opportunity of laying out lines of drainage in the most judicious directions; and looking at the question as one of mere economy, without reference to the advantages of better drainage by greater falls and quicker flows, it has invariably been found that the saving of public sewer alone rendered practicable by the detailed survey, amounted to many times the actual cost of the survey, and that one half of the cost of private house drains might be economised by aid of the same guide."

With reference to the new survey of the metropolis undertaken by the Ordnance Survey Department at the recommendation of the Metropolitan Sanitary Commission, and now in course of completion, the General Board of Health remark in their report on the water supply:—

"By the aid of this survey, combined works may now be executed with certainty. Under the present method, according to which water works are laid down piecemeal, and in disorganised portions, the mains are separated from the other and most important part, the apparatus for the delivery of water into houses, and under this system an accurate system of levels is not apparent. But by means of the accurate levels set forth on the survey, the inclines and directions of the branches may be determined, with the effect of saving considerable lengths, and of securing the greatest amount of flow and the readiest supply of water at the least cost. By the system of levels, the relation of every minute portion of the work to the whole system, the degree of pressure and strength of the apparatus required in any room, the height and force of the jets; and the quantity of water delivered for any purpose on any spot and the average pressure of the water supply in any district; may be known and regulated at any period; whilst, every workman engaged in the execution of combined works in the dark and densely crowded districts, may be guided by the survey in laying down house and branch drains for the discharge of soil water at the proper inclinations, and in directions having correct relation to works often at several miles distant. By the levels taken for this survey, the waste in laying out extensive lines of sewers with no fall, or with falls the wrong way, waste such as that of laying out a table of drainage, including an entire district in such imperfect relation to other districts as would involve in the opinion of the chief surveyor, an expense of upwards of £250,000, to set the levels right, may be prevented; and the whole of the public works of the metropolis, including roads may now be placed in correct relation to other works.

"The General Board desire to lay stress, at the present time, upon the importance of this view of the subject alone; but, surveys sufficient for sanitary purposes, will be permanently available for all others, and will prove of great value for the complete map delineation of many classes of information. In the general consideration of the necessity of such plans for the purposes of the Public Health Act, the General Board have not overlooked these several other uses to which they may be applied, tending in various ways to much ultimate improvement and advantage.

"Besides the more immediate uses of plans, therefore, for the complete delinea-

tion of main and house drainage, water works, gas works, and pavements, specimen plans have been prepared, exhibiting among other things, the value of such surveys in the registration of property, in street and building improvements, in valuations and assessments, in rate collections, and in the records of public officers, the District Surveyor, the Officer of Health, the Registrar, the Relieving Officer, and the Police. Plans adapted to these additional uses might be made to present in time a complete historical record of the progressive improvement of town populations of greater national value than any registration in books.

"In order to lay out with completeness and efficiency works of improvement under the Public Health Act, two plans will be required to be prepared from the survey, one a general plan to a small scale, affording a complete view of the entire district, and the other a detailed plan of the town portion of the area.

"The scales proposed by the General Board of Health are for the general plan two feet to the mile, and for the detail plan 10 feet to the mile.

"In fixing the scale of the general plan it appeared to be desirable that it should be so small as to afford a complete view at once of the entire district under consideration but at the same time large enough to admit of the accurate measurement of areas of land and other general uses. For the first consideration a smaller scale than that proposed would have been equally serviceable, but the experience of the Tithe Office has found that areas cannot be determined with the required accuracy upon a less scale than three chains to an inch. A scale of two feet to the mile has been adopted as the nearest approach to the tithe scale that would form an aliquot division of the scale of the detailed plan.

"A complete system of levels should form one most essential feature of the general plan. In the practical carrying out of proposed works the general board have every reason to believe that a great number of fixed points of level, which can at any time be found and referred to on the ground, will be of infinitely greater service than any system of contour lines, which, after they have been levelled, have no existence but on the plans. The comparatively small value of a system of contour lines does not appear to warrant the very large expense of their execution, more particularly as with an extensive system of fixed points of level for guidance, the general configuration of the ground may be lined out by the surveyor on a small scale plan with sufficient accuracy for all the purposes for which contour lines are generally serviceable.

"The scale of the detailed plan has been determined mainly by the experience of what is required for the complete exhibition of all the particulars of main and house drainage; for it has been found that any scale large enough for this purpose would be sufficient also for any other service for which a complete and detailed map would be required.

"Prior to any decision on this important point, considerable trial was made of various scales, and all available experience sought upon the subject. The scale adopted is an inch to 44 feet, or 10 feet to the mile.

"The Ordnance Town Scale is only one half of this, or five feet to the mile, but in some towns in which recent surveys have been made, considerably larger scales than now proposed have been adopted.

The Town Council of Liverpool have had a plan executed to a scale of 22 feet to the mile, notwithstanding that the ordnance had already made a survey of that town to the scale of 5 feet to the mile; but the trials which have been made by the General Board, and the experience on the subject obtained in the metropolis, have clearly shown that while, on the one hand, so large a scale is inconvenient and unnecessary, the Ordnance Scale for Town Surveys first

adopted in Ireland is, on the other, quite inadequate to the puposes for which the plans are now required.

"Provided that the scale is sufficiently large for the proper exhibition of the most crowded subject matter of information—the house drainage, it appears to be far more desirable, for the clear exhibition of the various particulars required, that the separate classes of work should be shown on separate copies or tracings of the plan, than that the scale should be enlarged for the purpose, for no practicable enlargement avoids the confusion which arises from crowding these different classes of work, however imperfectly, upon the same plan.

"There is one essential feature in the specimen plan, which has not hitherto received attention, and without which no attempt should be made to lay out works of drainage, that is, the level of the basement or lowest floor of every house. In the absence of this information, it continually occurs that sewers are laid down some feet higher than the places they are intended to drain, and the sewers drain into them instead. The great object of the deep drainage of towns is effectually to carry off the refuse from habitations, and yet works are constantly executed without any certainty of accomplishing this special object. The General Board have already had presented to them, under the Public Health Act, plans for approval, in which no information whatever has been obtained on this point, and in which there was not the least security that the sewers would not be laid above the level of the basement."

To resume my subject, the main drains having been marked out on the map, the next consideration is, the size they will require to be constructed, to fulfil all the uses for which they are intended; at the same time it should be forcibly borne in mind that the less the diameter of the sewer is in excess of its actual requirements, the easier it is to be constructed, the cheaper will be the present cost and future repairs, and the easier and more effectively will it cleanse itself with the aid of the ordinary sewer water. It is a very common error to assume that a sewer to a reasonable size cannot be too large; and it is the most certain course for the inhabitants of a town to take, upon the first mention of improvements of this nature, to set about framing extravagant estimates of the cost of a sewer large enough to drain five times the amount of their population, as though there were no medium between the absence of drains in their town, and the existence of sewers that would require the full force of a large river to keep them clean.

It has been found in many instances, upon opening large sewers that have become stopped up from a supposed inability to carry off all the water they have been required to do, that the sole reason has been the deposit of cesspool matter, accumulated beyond the power of water to remove it, and leaving but a mere fractional part of the sectional area of the sewer for the passage of the water.

Fig. 183 represents a large sewer in the metropolis, and the condition in which it was found by the officers of the Sewers Commission. The space occupied by the ordinary run of the sewage in the form to which it had worn itself, is shown near the crown of the arch.

Figs. 184 and 185 represent two instances in large sewers in which the actual requirements of the run of the sewage is depicted in a smaller amount of deposit. It will be seen by these examples that a pipe sewer would have carried off all the ordinary sewage water, and, as has been previously advanced, would, in its passage, have carried off all the matters which formed the deposit in the larger one.

The notion that large sewers must be used to carry away an occasional excess of storm water is at once refuted by these examples, for since accumulations of this kind will continually take place under ordinary circumstances, these extraordinary occasions find no greater accommodation in the larger sewer than in the smaller one.

The proper functions of sewers are obviously to convey away from a town the whole of the sewage refuse of every house in the district, the accumulations of foul matter in courts, lanes, and alleys; and so much of the rain-fall of the district as may fall upon the surface of the roads, streets, courts, &c., the roofs of buildings, and of yards, or other spaces attached to them; but to attempt to provide for the subsoil drainage of the site of the town by any other than the natural means, or an independent system, totally separated and distinct from the sewers, is expensive and futile.

If the whole of the rain or storm waters falling upon the streets and buildings of the town is conducted away in the sewers within a reasonable space of time after it falls, and the whole of the house drainage is provided for in the same way, what can be the amount of dampness or moisture from below that it may be necessary to be careful for?

In determining the capacity of sewers, we therefore have to ascertain, the amount of house drainage to be provided for, by estimating the number of houses we intend to drain into the sewers, and by assuming that each house will, in a given time, discharge a certain quantity of sewage. This calculation is of necessity only an approximation, but it will be found to be a useful one.

For its basis, we may consider that each house contains on an average five individuals, and that for every individual

twenty gallons of sewage matter, including waste water from all household sources, will pass into the drain in the course of the day.

The maximum rain-fall may be taken as two inches in any one day, and may be computed on the total area of site occupied by streets, houses, buildings, yards, and gardens, according to circumstances, and the probability of the whole or chief part of the bulk being discharged without evaporation into the sewer.

We have taken the house drainage and rain-fall of one entire day of twenty-four hours; but inasmuch as the drainage is exceedingly irregular and uncertain, and not at all likely to be spread equally throughout the whole time, and a July storm may cause a large accumulation of surface water in a very little while, it has been deemed advisable by very able and experienced practitioners to allow for the possibility of the combined quantity being discharged in two hours.

It frequently happens that a few straggling houses stand in grounds of considerable extent, but it must not be understood that the calculation for rain-fall is to be computed on such sites; it has already been explained that for the drainage of such properties the natural drainage out-fall of the district must be resorted to, as it would hardly be sanctioned by the loudest economists to build a sewer sufficiently large to provide against inconvenience such as this, which may not arise twice in the year.

Having arrived at the approximate quantity of sewage matter to be conveyed away by the sewers in two hours, and having allowed some additional quantity for the probable increase of the neighbourhood, if we divide the sum in the aggregate, reduced into cubic feet by 120, we get the quantity per minute, which at once identifies us with our Tables. But the quantity we have now obtained is the total quantity at the outfall, and the sewer will not be required to accommodate so large a supply throughout the entire length of its course; it will be expedient, therefore, in the first place, to consider such a length of it only, commencing from the outfall, as partakes of no very great diminution, and by taking the rate of inclination from the section, ascertain from the Tables the size of pipe that will be necessary to fulfil the requirements. Other portions may then be taken, and the sewer may be gradually diminished in size, as the purposes for which it is intended may become lessened in extent. It may, however, be well to limit the minimum size of a main or principal sewer to nine inches of clear internal diameter, thence increasing to twelve, and reaching its maximum at fifteen.

If it becomes necessary to exceed the diameter of fifteen inches, it will be desirable to resort to the old description of brick sewers; consequently, a few words with reference to the most approved form of such drains, will be in consonance with the object of the present work.

The form of a sewer should be conducive to strength, at a minimum cost; hence the adoption of the circle, as a form offering to all the exterior parts of the surface a uniform resistance to pressure from without. But the top, sides, and bottom of a sewer are not required to sustain a uniform pressure, being acted upon in very different directions, the greatest amount of pressure being vertically, and consequently the greatest ability to resist pressure should be above and below, the sides being more or less tried, according to the nature of the surrounding soil, and its ability to support itself by its own tenacity.

As fluids flow with greater velocity the less they are exposed to friction, the best description of sewer must be that which offers under all circumstances of more or less supply, the least amount of surface in contact with the fluid.

It will, therefore, be seen, that what is called the "Egg-shaped Sewer," which is illustrated in fig. 186, affords in the greatest degree the two considerations we have been discussing, viz., "strength vertically," with the advantage of a confined channel, and a "minimum amount of surface exposed to friction," under all circumstances, of much or little matter in the sewer.

This form of sewer is simply constructed by observing the following proportions:—Let the diameter of the lower arc be 1; the diameter of the upper arc 2; the height of the sewer 3; and the radius of the side arcs 3.

In computing the capacities of *brick sewers*, the values given in the Tables must not be depended upon, as they are based upon the discharges of pipes having a glazed internal surface, through which the sewage matter passes more freely than the surface of the brick sewers will allow it to do. The discharge will, therefore, be considerably less, more or less varied, according to circumstances, but probably 30 or 40 per cent; the pipes being altogether better suited to the purpose.

It is interesting to investigate the varied powers possessed by water in motion under different circumstances. A stream of water 4 feet wide and an inch deep, with a fall of 1 in 150 is sluggish, while the same water running through a 12-inch drain pipe, laid at the same rate of inclination, flows at a considerable velocity.

The former would deposit silt or sand, the latter would certainly remove it.

One very great objection to large drains is the necessity of cleansing them by manual labour.

The legislature has very properly prohibited the sweeping of chimnies by boys as an occupation degrading to human nature, eminently cruel, and belonging to a low state of art; but that occupation was a princely one as compared with the employment of cleansing sewers by hand. Instances have occurred of the death of men who have been sent to crawl up sewers charged with foul gases, while many have had their health irreparably injured in this disgusting labour for their daily bread.

The following are extracts from some of the reports of the surveyors employed upon the subterranean survey of the metropolis, recently conducted for the Metropolitan Sewers Commission:—

"69½ miles of sewers have been surveyed in the Surrey and Kent district. The surveyors find great difficulty in levelling the sewers of this district; for, in the first place, the deposit is usually about 2 feet in depth, and in some cases it amounts to nearly 5 feet of putrid matter. The smell is usually of the most horrible description, the air being so foul that explosion and choke damp are very frequent. On the 12th January, 1849, the surveyors were very nearly losing a whole party by choke damp, the last man being dragged out on his back (through 2 feet of black fœtid deposit) in a state of insensibility. Another explosion took place on the 12th February, in the Peckham and Camberwell Road sewer, and one on the 21st February, in the Kennington Road sewer; in both cases the surveyors had the skin peeled off their faces, and their hair singed. Two men of one party had also a narrow escape from drowning in the Alscot Road sewer, Rotherhithe, on the 24th instant; but fortunately none of the foregoing cases were attended with serious damage.

"The sewers on the Surrey side are very irregular; even where they are inverted they frequently have a number of steps and inclinations the reverse way, causing the deposit to accumulate in elongated cesspools. It must be considered fortunate that the subterranean parties did not first commence on the Surrey side, for if such had been the case, they would most undoubtedly have broken down."

These surveyors report that in the modern district of Belgrave and Eaton Squares, although the brickwork of the sewers is generally sound and good, they contain several faulty places, and abound with noxious matter, in many cases stopping up the house drains, and smelling horribly. In the neighbourhood of Hyde-park Gardens, and the costly squares and streets adjacent, the sewers abound with the foulest deposit, from which the most disgusting effluvia arises.

It has been estimated by professional men that the whole evaporating surface of stagnant and pestilential matter beneath the

houses and streets of the metropolis is equal to a canal 50 feet wide, 10 miles long, and 6 feet deep, and that it would form a putrid swamp nearly 800 acres in extent, or nearly three times as large a surface as the whole population could lie down upon.

Without any reference to the injury to health that must inevitably result, even to the strongest constitutions exposed to such emanations, or how insensibly yet fatally they prove when concentrated upon the weakly, and without any reference also to the very great cost of such large sewers, I submit, that on the question of efficiency alone, I have shown ample reason for their abandonment, excepting under the most urgent contingencies.

The main sewers having been laid out and their sizes determined, the arrangement of the house drainage next demands our attention.

Perhaps no branch of the constructive art has received greater improvements from science, than the formation of house drains.

Prior to the year 1846, it was the custom in the metropolis to construct house drains, either square or circular, 12 or 9 inches in width or diameter, the latter being the minimum size permitted by the regulations. These drains were constructed either of brick or stone, emptying into large brick sewers 5 feet to 5 feet 6 inches in height, 2 feet 6 to 3 feet in width, with curved top and bottom and straight sides. The expense of this method amounted to about ten guineas per house.

In 1846 this system was modified, under the direction of the Westminster District Sewer Commission, a six inch pipe was substituted for the former house drains, discharging into an egg shaped sewer 3 feet 3 inches by 1 foot 9 inches in courts from 300 to 400 feet in length, 2 feet 9 inches by 1 foot 6 inches, in places varying from 150 to 300 feet in length, and 2 feet 3 inches by 1 foot 3 inches, in places less than 150 feet in length.

The expense of this improved system averaged about five guineas per house.

About the year 1849 a system of back drainage was introduced into London by the surveyors of the Metropolitan Commission of Sewers, which, for economy and efficiency, surpassed every thing of the kind that had preceded it to an astonishing degree. A great number of house drains were laid down, composed of glazed stone ware impermeable pipes four inches in diameter, and instead of the previous system of leading the drainage (the most deleterious portions of which are generated chiefly in the back premises) through the house, into the main sewer in the middle of the street, favoring to the utmost the emission of effluvia in the passage through the house, and having, moreover, to pass over a considerable space,

with the least possible declivity and proportionate velocity, the new system concentrated the sewage in smaller drains at the farthest possible distance from the houses, and conveyed it away from them with far greater velocity produced by the increased inclination consequent upon the shortened length of drain. The junctions too were formed so as to interfere, as little as possible, with the flow of the sewage being made curvilinear, instead of the right angled construction of the old system. In addition to all which advantages, the expense of construction is reduced to its minimum.

Plates 13 and 14 are two plans of the same block of 40 houses, and will illustrate the old and defective system, as well as the improved one now recommended.

In this block, the total length of drains by the old separate system is 2,956 feet, by the improved system of back drainage 1,300 feet; while the cost is considerably less by the latter than by the former arrangement.

The sizes of house drains will, of course, become the subject of calculation, in the same manner as the larger drains. Three inch pipes are recommended to be the minimum, and six inches will be found sufficiently large for the maximum.

Besides the advantages of diminished friction, economy in construction and improvement in form, obtained by the use of pipes for house drains, a positive gain in fall is obtained, without altering the relative position of the drain. The height of a nine inch barrel drain with a 4½ inch rim is 13½ inches above the level of the outfall, while the height of a 4 inch pipe is but about 5 inches. So that, if a drain 60 feet long would require, if constructed in brickwork to be laid level, the pipe might have a fall of more than 8 inches, equal to an inclination of 1 in 90, and this gain would be considerably more important and apparent, if the length of drain were shorter, such, for instance, as the case of a drain in a court yard 10 feet long, to which the gain of 8 inches in the fall would impart an inclination of 1 in 15, and a capacity to discharge 245 gallons of water per minute, while the old brick drain would not discharge 30 gallons in the same time.

I will now add a few words relative to the new theory of back drainage, in addition to what has been previously advanced. Besides diminishing the length of the drains in the aggregate, and so increasing the velocity and reducing the expense, great improvement is effected in each separate drain. Water is chiefly used in and about the back offices of houses; closets are generally situated there, and thence the discharge of waste water will principally be.

I have already noticed the common practice of placing sewers for the reception of house drains, so as to compel the necessity of passing the drain across the court yard, underneath the basement rooms of the house, under the foot paving and into the middle of the carriage way; while by the new system, the drain is not required to be nearly so long, and hence the rate of inclination is considerably greater.

Figs. 189 and 191 are plans, and figs. 188 and 190 are sections of a house, which will illustrate this more fully. The plan, Fig. 191, shows the old system: C is the sewer in the centre of the street: A is the closet in the yard and B in the house. The plan from A and B to C displays the proportion of noxious evaporating surface formed by the house drains.

The lines from A and B to C, in the section, fig. 190, show the proportion of the capacity of the drains and so much of the sewer as are unoccupied by deposit, to act as reservoirs of foul gases.

The plan, fig. 189, is illustrative of the improved system. The diminished extent of evaporating surface obtained by the pipes, supposing them to be proportionately occupied by ordure, will be apparent, but when the pipes are properly laid, they will keep themselves perfectly clear of all deposit.

The section, fig. 188, of these improved drains exhibits a rapid fall, in place of the slight inclination under the old system.

One other great desideratum of improvement possessed by the new system over the old, must not be omitted a notice. When a stoppage takes place in one of the old description of drains, it frequently can only be rectified by taking up, first the carriage way, next the foot paving, then the flooring of the front and back room, and, finally, perhaps the paving of the yard. Under the new system, this latter operation is all that can possibly be required.

The rats, too, had the means of conducting the noxious effluvia from the old defective brick drains into the house; but the glazed stone ware pipes prevent them the exercise of this mischievous pastime.

Before I take leave of this part of my subject, I must state, that all the improvements I have suggested and explained will be entirely futile, unless works are skilfully and properly executed; and I am firmly of opinion, that so far from the professional man's fee being thrown away for advice in matters of this nature, it will very frequently save double its amount in present outlay, besides rendering the expenditure serviceable to the purposes for which it is intended. I never yet knew a case of failure of pipe drainage

that did not result from some accountable cause that should have been avoided at the commencement; and so rapid is the flow of the sewage in some of the well-constructed pipe drains, at good inclinations, that pieces of paper in a perfect state have been observed to pass the outlet of the sewer.

A word on the subject of junctions for house drains will but occupy an appropriate place in a paper of this kind. The general custom with engineers and surveyors was to make the junctions of house drains at right angles. Experiments have proved that while a given quantity of water running direct in a drain was discharged in 90 seconds, it required 140 seconds to discharge the same amount of water from a drain of equal size and fall which turned at a right angle, but 100 seconds only was required with a drain laid in a true curve. A house drain at right angles, whether horizontal or vertical, is vicious in principle; the sewage will never flow so freely as in one properly constructed, and accumulations will constantly take place. The right-angled junction for horizontal drains is pretty generally abandoned at the present time, but it is still erroneously continued by some for vertical drops.

Exactness of workmanship, both in the make of the pipes, and in the method of laying them is equally as essential as the skilful arrangement of the drains throughout the house; for, from what has been said, it must be evident, that in a proper system of drainage, water is not required to clear away accumulations, but to prevent their ever forming.

Cases will frequently occur in which a junction of a four-inch branch with a four-inch main will require no additional capacity in the main to receive the sewage of the branch, the additional hydraulic pressure counteracting the effect of the additional quantity; and the same may be said of other sized branches and mains; but in all cases when such is not the fact, the main should be increased by a tapering pipe.

When drains are left to the management of bricklayers without professional supervision, it is not at all an uncommon circumstance, indeed, I dare say, I may call it a "common one," to increase or diminish the size of a drain by pushing the end of the smaller pipe into the larger one. I have also seen a man very busily engaged cutting a hole in a pipe into which to insert another, and thus form a rude junction; the result of these practices is a speedy failure of the drain, a wholesale condemnation of the system, and an increased additional expenditure on some more favoured but far less scientific substitute.

In passing in review the works of house drainage, as recom-

mended under the new system of back drains, we find that we must provide to every closet, sink, court yard stone, and roof or stack pipe, a 3 or 4 inch drain, communicating by proper curvilinear junctions with the main sewers, and these must be properly trapped.

With reference to the mode of trapping house drains and of preventing the egress of foul gases into habitations, the best form, because the most economical, simple, and least liable to derangement, is the common syphon trap, which being made of the same material, and of the same guage and length as the drain pipes, is readily adapted to its purpose, and may be inserted at any interval or in any position along the drain. It is a very popular error, that the new system of drainage requires better traps than the old. Nothing is more common than for an engineer to be told—"Ah! now that we have these new drains, we must take care that they are well trapped, or we shall be in a fine state." Why the best protection we can have against inconvenience of this nature is, the removal of all masses of decomposing matter from beneath or near habitations before decomposition can have advanced, and before any part of it can get into those ultimate stages of decay which in the present, or perhaps I ought to say, old methods of town drainage, it usually reaches before removal. It has been found by an experience of three years, that house sewage, drained through impermeable pipes into a water-tight tank, may be stored even for four or five days without becoming offensive.

It should be borne in mind that such sewage, so stored in an impermeable receiver, differs very strangely indeed in its degree of fluidity and other qualities from the noxious contents of an ordinary cesspool, from which the more fluid portions are constantly oozing.

I might, perhaps, advance a few observations on the construction of the chief apparatus for the decent and efficient sanitary arrangement of every house—I mean the water-closet. It is a room to which but very slight attention is paid by too many of our population, with the machinery of which too many are wholly unacquainted, and of the importance of attention to the perfectness of all its parts, more especially the apparatus for preventing the effluvia from returning into the house, so few are sufficiently alive. But my chapter has already extended far beyond the limits within which I originally intended to confine it. I will, therefore, simply suggest, that the chief points to be sought in the construction of the apparatus appear to be:—

1. A sufficient spread of the water to effect a complete scour for the removal of the soil;

2. Economy of water to effect the scour and replenish the trap;
3. The best trap to prevent the ingress of the effluvia from the general system of drainage, with which the apparatus must be in connection, and also to prevent the return of any effluvia from the soil of the closet itself;
4. Freedom from stoppages;
5. Non-liability to derangement;
6. Facility for repair; and
7. Economy in price.

The effectual removal of rain and storm water from the surface of the public highways, will require a grating at properly regulated intervals, on either side of the street, according to the nature of the road and the rate of inclination. These gratings must be made to communicate with the main sewer through a properly constructed trap and pipe drain. If the road be a Mac Adamized one, some contrivance will be necessary to intercept the detritus that will pass the grating from entering the sewer, to which it is very injurious by reason of the short time in which it concretes, and forms an impediment to the flow of the sewage. Fig. 192 is the plan, and fig. 193 the section, of a trap and cesspit, which has been advantageously used in many cases, and of which favourable reports have been made. Fig. 194 is a plan, and fig. 195 a section, of an extension of the same principle by means of a double cesspit; but in either case, periodical cleansing with water is required. The surveyor to the Preston Local Board of Health has adopted an extra grating placed within the cesspool in a vertical position over the mouth of the shoot, the advantage of which is, that the street grating may be made of such a width as not to be liable to become choked.

A perforated plate would be preferable to long bars, through which substances of considerable length although narrow can easily pass.

The manufacture of earthenware pipes for drainage purposes dates only since the year 1842, when the sanitary enquiry gave rise to their adoption, and since that time the demand has been so great, that manufacturers have given very little attention to improvements which, under a less extensive demand, and with greater competition, must have been inevitable.

As much as 35 per cent. upon the prices advertized was offered to me by a manufacturer if I could procure him the order for about £1000 worth of pipes required in the drainage of a provincial town to which I was acting as engineer. Such an offer is quite sufficient to convey an idea of the large profits which have arisen in the

trade; and I only notice it here, to justify any person purchasing drain pipes, in insisting upon perfect symmetry and workmanship in the articles that are supplied him.

The first joint that was suggested to these stoneware drain pipes was, the "*butt joint*," which simply consisted in pushing one pipe against another, and joining them as well as might be practicable. This was soon improved by the introduction of the *socket joints* The objection to these pipes principally consists in the difficulty of opening the drain in case of necessity, as it will be evident that if the flanges or sockets are sufficiently long, a pipe must be broken to accomplish an entrance to the drain. To obviate this, pipes with *half sockets* have been used, the socket extending only on the under side of the pipe; and it has been suggested, that one moiety of the pipes to be used should have one of these half sockets on either end, while the other moiety should be without sockets, so that every alternate pipe, as it were, drops into its place upon the half sockets of the pipes before and after it, and could of course be removed with equal facility.

Another suggestion gave rise to the adoption of a pipe to be laid at intervals along the drain, the upper half of which could be removed, and thus afford the means of more readily ascertaining the point at which a drain might have become choked, or for the insertion of a junction. This pipe, however, will not efficiently answer the purpose of such pipes, it cannot be impermeable, and consequently should not be used.

An objection to any socket at all on the pipes arises from the fact of its interfering with the proper laying of the pipe, which generally acquires a bearing upon the flange without being bedded in the centre, and consequently its liability to be broken is much increased. As an improvement upon this, the rabbeted cone junction pipes have been introduced. The drainage of Croydon has been (I believe) entirely carried out by pipes of this make.

Upon the question of laying the drain pipes, making the excavations, joints, junctions, traps, and such like, I omit a description here, as full particulars will be found contained in one or other of the specifications appended to this chapter.

Water Supply.

We next come to the question of Water Supply, and unlike the drainage question, in which our first concern was to look out for a place of deposit, we now have to do exactly the reverse, and to find the purest and best *source* from whence we may obtain a supply.

According to the highest authorities, the qualities for the water

supply of a town population range themselves in the following order:—

1. Freedom from all animal and vegetable matter especially matter in a state of decomposition.
2. Pure aeration.
3. Softness.
4. Freedom from earthy or mineral, or other foreign matters.
5. Coolness in delivery, at a medium temperature, neither warm in summer, nor excessively cold in winter.
6. Limpidity or clearness.

If the slightest taste or smell is perceptible in water, some foreign matter is present which should be expelled if possible, the smell either denoting organic matter in a state of decomposition, or some insalubrious mineral property. If water is tinged with colour, it is caused by earthy or vegetable matters which require to be removed by filtration.

In seeking a supply of water for all the uses of a town population, it is doubtless desirable, if possible, to avoid the adoption of a river source in which the water may possess many degrees of hardness; but if the natural physical features and the geological stratum of the surrounding country, do not present that facility for obtaining a supply of soft water from gathering grounds, it certainly becomes a question of expediency whether the waters of the river source cannot be so far purified from animal and vegetable matter as to render them eligible for the purposes required.

Those towns that are without the presence of a neighbouring river are generally well situated for obtaining an abundant supply from gathering grounds and storage reservoirs. Water obtained from such a source will undoubtedly be more or less superior in quality according to the soil and subsoil of the lands upon which it is collected. The less the interval during which rain water remains upon the surface, the smaller must necessarily be the impurities it will take up during that time. And again, the smaller the surface over which it is driven before it can percolate into the land, the smaller will be the amount of organic matter with which it will become impregnated.

If the town to be supplied has in its vicinity a sufficient area of hill lands at an elevation to enable the collection of the required quantity of water, and its storage in a reservoir situated above the level of the top floors of the highest houses in the town, that is of all others the most desirable site for gathering ground because all lifting of the water by pumping will be entirely obviated,

and every house, indeed every room in the town, may be supplied by the natural power of gravitation.

The method of catching the rain fall of an elevated area must be varied according to circumstances. For manufacturing purposes in the North of England the practice has been to cut a certain number of catch water ditches around the apex of the hill, in the form of contour lines, varied of course according to the extent of the gathering ground and other physical features; and below these catch water contrivances, to construct a reservoir, regard being had to the relative elevation of the reservoir and the place at which the water is required for use.

Large pasture lands on a sharp sandy or gravelly porous soil incumbent in a clay subsoil, offer the most geological advantages for gathering grounds; and the modern method of land drainage by permeable pipes is probably the best mode of collecting the water. The impurities held in suspension by the water are disturbed in its passage through the sand, and the organic and other matters held in solution are seized upon by the growing herbage, so that water so collected will flow from the pipes in a state superior, generally speaking, to water from all other sources. If no gathering grounds can be found of sufficient altitude to supply the town by natural gravitation, the water must be lifted to a reservoir on a site that is high enough for that purpose. It will be found far more convenient to lift the water previous to storage than afterwards, because if the water is supplied to the inhabitants by gravitation, the pipes will always keep themselves full and a constant service may result. The pumps will then only be required to work as water from the collecting pipes requires to be lifted to the reservoir. Water from deep wells may be sometimes found free from animal, vegetable, and mineral impurities, and in such cases it only becomes a question of pecuniary expediency as to its use.

In estimating the quantity of water that may be collected by means of gathering grounds, the first information must be, the average rain fall of the district, and in estimating the proportion of that fall which may be reasonably expected to be collected and stored, considerable attention must be given to the absorptive properties of the surface soil, and also to the nature of the subsoil. The first should allow the water to soak into the land as fast as it falls, and the latter, if impervious, will allow little to pass the pipes and be lost.

If water can be collected by means of land drainage, such as we have hinted at above, and from a bed of vegetation, such as pasture grasses, on sandy or gravelly soils, it will require no filtration

if properly stored in a well constructed reservoir, a better filter than this natural one being beyond the power of science to suggest.

It will take about an inch and a half of rain-fall on an acre to supply a house with the quantity of water we have herein assumed to be the proper supply, viz., 100 gallons per day, (always bearing in mind we are speaking of an average; a house with six inhabitants having 120 gallons, while one with four inhabitants has but 80 gallons), so that if we can save nine inches of the annual depth of fall, every acre of gathering ground will supply six houses; and for a town of 6000 inhabitants, or (at our average) 1200 houses, 200 acres of gathering ground will be sufficient.

In computing the expense of this mode of collection, much will again depend upon circumstances, the price of pipes, and skilled labour in the neighbourhood, but £6 per acre may be pretty safely taken as the maximum, against which a considerable set-off may be generally calculated on from the owner of the soil, whose land would be benefited by the execution of the works. But if we take the full cost as a first outlay it amounts to £1200, or £1 per house on the houses benefited, which may be said to be placed in the same position as they would be by the sinking of a well on every premises, with this advantage, that the water in the former case is ample in quantity and pure in quality; while in the latter it is often scarce, or else so hard as to be unfit for many domestic purposes, and so contaminated with the percolation of the neighbouring cesspools as to be injurious to health and unpleasant to taste.

It may be useful to bear in mind that the quantity of water here allotted to each individual, is a very bountiful allowance. Some engineers, I am aware, estimate one inch of rain-fall per acre as sufficient to supply each house, the allowance being about 62 gallons per day, or assuming the average of five occupants, 12 gallons to each person. It is no doubt as essential to have quantity as quality, but still, if instead of finding that a town of 1200 houses possesses an eligible gathering ground of 200 acres, we find only 130 or 140 acres; we may nevertheless consider that with an occasional auxiliary supply for those purposes in which quality is not a consideration, such a town to be well supplied.

The next question that will demand attention, whether we adopt the gathering ground as a source of supply, or whether we obtain our water from a river or a well, is the storage reservoir. In elevation we have already said this should be sufficient to serve the highest houses in the district, in their upper floors, by the simple

power of gravitation. In size it will be guided by the source of supply; if this is from a river or a well, a capacity to contain enough for six days' use will be ample, because the pumps may be worked at any time, the six days' being only provided as a provision in case of accident; but if the supply is from gathering grounds, calculated upon a basis which assumes that none of the water falling thereon shall be wasted, our reservoir must be sufficient to hold the excess of the supply above the demand in wet seasons, to provide for the deficiency of supply in seasons of long draught. If we assume that a reservoir should contain a four months' supply, we shall appear to make ample provision for this irregularity. If our reservoir is within reasonable dimensions, it should be certainly covered over, and the light should be excluded. A reservoir intended to contain the four months' supply just spoken of could hardly be so treated. In all cases, the reservoir should be constructed as deep as possible; but this is of less importance in a covered reservoir than in an open one, the great desideratum being to prevent as much as possible the rays of light from exercising any objectionable influence upon the purity of the water.

Having determined the site of the reservoir and the size, we come next to the consideration of the course and direction of the service mains. The same desiderata should now occupy attention as influenced the laying out of the main sewers. Friction should be avoided as much as possible, and a regular inclination will insure a more steady pressure upon the pipes. In calculating the sizes of the mains, a distinction will become apparent between a constant and an intermittent system. In the former we may with tolerable security assume that the whole of one day's supply will not be required in a less space of time than four hours; while in the latter, the cisterns of the inhabitants will be filled in a time, limited only by the capacity of the machinery adopted for the purpose.

A few words on the comparative merits of the two sources of supply may not be out of place.

The expense of erecting cisterns, and the necessary apparatus for the intermittent system in new houses of the first class in the fashionable districts of the metropolis, rarely comes under £100 per house; and in one block of building, the details of which have come under my observation, the expense of cisterns, ball-cocks, and extra pipes amounted to £900, of which £500 was for the cisterns alone; whereas £200, or, at the most extravagant estimate, £300 would have furnished the means of a better supply by the constant system. In all towns that are supplied with water under

the constant system, the advantages are apparent in the immense saving of water, and the general comfort and cleanliness of the inhabitants, without reference to the pecuniary advantage above alluded to. Independent of other advantages, the quality of water suffers less deterioration under the constant than the intermittent system; and beyond doubt, the strain upon the mains and submains is not so severe, inasmuch as all hydraulic shocks common to the intermittent system have not to be resisted under a constant supply.

It is in accordance with common sense, that water exposed in a cistern out of doors, in a smoky neighbourhood, must soon become impregnated with the impurities that are floating about in the atmosphere in every possible direction; and if the cistern is within doors, the water soon loses its freshness, and acquires a slimy character. Under the constant system of supply, if all the pipes are made to communicate, a free circulation is kept up by the constant drawing from one pipe or another, and as nearly as may be the same quality of water is maintained throughout the town; the water always flowing towards the point of draught.

From what has been stated, it is evident that no town can be said to have a proper supply of water that does not give to every house a tap, from which an unlimited draught can be taken at any hour of the day and night.

That the establishment of apparatus to carry out the constant supply is less expensive, and that the water so supplied is better in quality than by any other method of distribution.

The basis of a calculation for the sizes of the mains being a given quantity of water required to be conveyed a certain distance in a certain time with a known head, the *Hydraulic Tables* will speedily determine the requisite diameters. It should be added, that in all cases where practicable, the water pipe and the drain pipe should be laid in the same trench, by which means a great saving is effected in the excavation and replacement of the ground in laying down the pipes. But in every case, the water main should be above the drain, so that all chance is avoided of any escape from the drain polluting the water service.

The sub mains and house services, stand pipes for street watering, fire plugs, stop-cocks, and other minutiæ of detail, will be laid out at the discretion of the engineer.

The method of carrying out the works on the ground we will endeavour to illustrate in the specifications annexed.

As much misconception exists with reference to artesian wells and springs, a word or two thereon may be appropriately advanced

under this branch of our subject. Some assert that an artesian well ceases to become so directly it ceases to throw up water, but such an argument is not tenable for a minute. An artesian well, so called from the province of Artois, in France, (at which place the practice of boring used in the construction of an artesian well was chiefly carried on,) is nothing more than an illustration of the old and well known hydraulic fact, that "water will always find its level." The theory of these artesian wells is very simple. Let the points A A, fig. 187, represent the exposed surface of a porous strata, perfectly absorptive of water, and on the contrary, let the points B B be the surface of a strata of tenacious clay, wholly impermeable; now if it be desired to create an artesian well at the point C, we shall have to bore through the impermeable clay, and while so doing, no discharge of water will take place; but as soon as we tap the porous strata at D, the water therein will rise to the surface C, and (if confined by a stand pipe) to such a height above C as shall correspond with the level of the water in the porous strata.

Inasmuch as it is possible to exhaust the supply, so will the working capacity of this well depend upon the extent of surface area of the collecting porous strata, as it must be evident that in a dry season the longer the well is worked the lower must the altitude of the water in the strata become, and the less efficient will be the discharge, and if rain does not replenish before the water in the earth is drawn to the level line E, the well can no longer discharge water above the surface, the hydrostatic pressure being all removed from it. But this by no means deprives the well of its character or right to its name, since no sooner is the water in the porous strata replenished by a fall of rain on the surface, than the well resumes its operations with a vigour proportionate to the fall of rain. Some porous strata stretch out so wide and offer so vast an area of exposed surface, that the water contained in them can hardly ever become exhausted.

What has been said with reference to artesian wells, will also serve to explain the properties of springs, which are only so many additional examples of hydrostatic pressure acting upon water contained in porous strata, which freely finds vent at the first place at which such strata becomes exposed to the surface of the earth at a low level. In Mr. Weale's Rudimentary Treatises will be found a little work, entitled, *Well Digging, Boring, and Pump Work*, by John Geo. Swindell, R.I.B.A., which will be found to be a most able though brief elementary description of this question.

Before finally closing this subject, I will observe, that the re-

gulations of good drainage can hardly tolerate the existence of old cesspools, and positively prohibits the creation of new ones within the vicinity of, or in proximity to, any collection of dwellings, of whatever description, as well as an untrapped connection with any drain or sewer.

SPECIFICATIONS, &c.

BIRCH END LOCAL BOARD OF HEALTH.

1853.

Contract, No. I.

IRON PIPES AND CASTINGS.

Specification to be *observed* by the *contractor* for making and delivering at the railway station at Birch End, certain *iron socket pipes* and castings, required for purposes of water supply by the Local Board of Health, Birch End.

Interpretation. In this specification the words "Local Board of Health," shall be understood to mean the Local Board of Health, for the time being, duly elected and acting in and for, the district of Birch End. The word "Engineer" shall mean, Edward Ryde of 14 Upper Belgrave Place, Eaton Square, London, Civil Engineer and Surveyor, or other, the duly appointed Engineer, or Surveyor, to the said Local Board of Health for the time being; and the word Contractor shall mean one or more Contractor or Contractors, and shall include his or their heirs, executors, and administrators.

Extent of Contract. This contract includes the manufacture and supply of all the pipes, cocks, and special castings that are required, to construct and completely finish the water works about to be carried out by the Local Board of Health.

Quality of Iron. The iron shall be remelted in the cupola or air furnace; and shall be of the best description without admixture of cinder, or other matter, to render it inferior in quality. It shall be strong, close grained, and tough, and shall be as hard as can be conveniently drilled and clipped.

Casting of Pipes. All the pipes shall be cast vertically in dry sand, and shall be of the kind, or description, usually denominated "socket pipes:" they shall be of the forms, thicknesses and dimensions shown in the drawings, and in case of any

discrepancy between the scaling and figured dimensions, the latter are in all cases to be observed.

Pipes must be sound and free from Defects.

The pipes are to be cast perfectly sound, free from cold shuts, honey comb holes, or other defects, and shall be truly cylindrical in the bore, straight in the axis, and internally of the full specified diameter. They shall be thoroughly cleaned, internally and externally, and great care shall be taken in cutting off the runners to preserve a square angle on the inner edge of the socket against which the lead joint is made. At the junction of the branch pipes the inside diameter of the outlet pipe is to be made half an inch larger than the other portions; and the thickness of the sockets shall be in all cases a quarter of an inch more than the body of the pipe. To insure that in all cases the beads will enter the sockets, a circular iron template shall be passed to the bottom of every socket, and a circular iron ring shall be passed over every bead. The socket shall not be larger than is absolutely required, and stated in the drawings, otherwise the expense of jointing will be unnecessarily augmented.

Pipes shall be proved.

The pipes are to be each proved before leaving the foundry under a pressure equal to a column of water 600 feet in height, and such pressure shall be maintained for at least three minutes, whilst the pipe is being sufficiently and repeatedly struck in every part with a hammer of weight suitable to the size of the pipe.

Engineer may attend at the Foundry.

The engineer is to be at liberty to attend at the foundry during the casting of the pipes or any of the special castings referred to in this specification, or he may depute a competent person to attend on his behalf, for the purpose of ascertaining that his instructions and the provisions of this specification are complied with; and the contractor shall at all times afford him every facility he may require, and pay immediate attention to any directions he may give.

Length of Pipes.

The two-inch pipes shall be cast in lengths of six feet; the larger sizes in lengths of nine feet; exclusive of the socket in either case, and shall be of the weights contained in the schedule hereto annexed.

Quantities of Pipes.

The probable quantities of the various pipes and castings required are set forth in the schedule hereto annexed; but it is to be distinctly understood that the engineer shall have the power at any time to make alterations in, additions

to, or deductions from, any part of this contract, which alterations in, additions to, or deductions from, shall not annul the contract, but an equivalent shall be given or taken as the case shall require.

Pipes, &c., to be coated with Dr. Smith's preparation.

The whole of the pipes and pieces, as soon as they are cast and cleaned, and before any rust shall have been produced upon them, are to be submitted to Dr. Angus Smith's patent process, in such a manner as to receive, while at the proper temperature, a complete and thorough coating of the preparation over the whole of the internal and external surface.

Contractor responsible for all flaws and defects in pipes.

Should the iron be of inferior quality, or the pipes too light, or any flaw or other defect appear in any of them after they have been delivered, the contractor is to be responsible for that defect, and is to replace the defective pipes with good ones to the satisfaction of the engineer.

Delivery of pipes.

The pipes and pieces are to be delivered by the contractor, at the railway station, Birch End, in such quantities and at such times, as the engineer may from time to time direct, the whole quantity to be sent in on or before the 31st December next.

Contractor responsible within twelve months.

In the event of the failure of any of the pipes within twelve months of their delivery, and the failure should arise from any defect in their construction, of which the engineer shall be sole judge, the contractor shall be held responsible for the damage, and shall on demand, refund to the Local Board of Health, any expense to which they may have been subjected by reason of such failure.

Cocks.

The cocks required are of the description commonly called, "double faced screw cocks." The shell of each cock is to be cast in one piece, and to be a sound clean casting, made from the best description of iron, and fitted up with bored and turned stuffing boxes, faced joints, and all the necessary bolts and nuts for the same. The spindles are to be of gun metal, with square thread, and each to be provided with a wrought iron box key head, cottered in. The valves of the cocks from two inches, to four inches in diameter, are to be of gun metal; above that diameter iron castings will be allowed, but with gun metal facings. Each cock must be perfectly tight, and of the best workmanship.

Engineer to have same power, and Contractor

All the powers conferred upon the engineer with reference to the pipes, in this specification, and all the re-

same liability with cocks as pipes.

sponsibility of the contractor shall equally relate to the cocks and other special castings, so long as the same is not repugnant to, or inconsistent with, any acknowledged engineering practice.

Special castings to be made as soon as possible after ordered.

All branches, bends, taper pipes, fire plug pipes, and special castings of every description shall be made and delivered as soon as possible after the receipt of the orders by the contractor.

Sureties.

The contractor shall, if so required, find two good and sufficient sureties, in a penal sum as nearly as may be equal to one quarter of the amount of the accepted tender, for the due performance of his contract.

Payment.

And the said contractor shall be entitled to payment for his work, in manner following, that is to say, 50 per cent. of the value of pipes and castings from time to time made and delivered, within one month of such delivery; forty per cent of the value of the whole of the pipes and castings delivered, within two months of the final completion and delivery of the whole contract; and the remaining 10 per cent. at the expiration of six months from the final delivery of the pipes, provided the said pipes have proved sound, or the balance of such 10 per cent., if any, as may remain due to the Contractor, after deducting any costs and expenses the Local Board may have been obliged to incur, by reason of any unsoundness, or failure of the pipes. Always premising that the certificate of the Engineer will be required, in all cases, before any payment will be made by the Local Board.

Schedule hereinbefore referred to.

Inside Diameter of Pipe in Inches.	Length of each Pipe in Feet.	Weight of each Pipe.			Probable number of each kind required.
		Cwt.	Qrs.	lbs.	
2	6	0	1	20	
3	9	0	3	20	
4	9	1	1	7	
5	9	1	3	0	
6	9	2	1	0	
7	9	2	3	0	
8	9	3	1	20	
9	9	4	0	0	
10	9	4	2	15	
11	9	5	0	12	
12	9	6	1	14	

Contract, No. I.

TENDER FOR PIPES AND CASTINGS.

We the undersigned Contractors will undertake to make and deliver, according to the specification annexed, the several probable quantities of pipes and special castings therein referred to at the prices stated below.

	per Cwt. £ s. d.
Straight pipes not exceeding 2 inches in diameter, at	
Curved pipes	
Taper pieces	
Branch pieces	
Straight pipes, exceeding 2 and not exceeding 4 inches in diameter	
Curved pipes	
Taper pieces	
Branch pieces	
Straight pipes, exceeding 4 and not exceeding 6 inches in diameter	
Curved pipes	
Taper pieces	
Branch pipes	
Straight pipes exceeding 6 and not exceeding 9 inches in diameter	
Curved pipes	
Taper pieces	
Branch pipes	
Straight pipes exceeding 9 and not exceeding 12 inches in diameter	
Curved pipes	
Taper pieces	
Branch pipes	
Cock and plug castings and other hollow castings not exceeding 3 inches in diameter	
Exceeding 3 inches and not exceeding 6 inches	
Exceeding 6 inches and not exceeding 9 inches	
Exceeding 9 inches and not exceeding 12 inches	

And we will undertake to execute an agreement (to be prepared by, and at the expense of, the Local Board) for the due and complete fulfilment of all the conditions expressed, and implied in and by, the specification hereto annexed.

Gentlemen,

Your most obedient servants,

CONTRACTORS.

BIRCH END LOCAL BOARD OF HEALTH.

1853.

Contract, No. II.

STONE WARE DRAIN PIPES.

Specification to be *observed* by the *Contractor* for making and delivering at the Railway Station, at Birch End, certain glazed stone ware tubular socket pipes, half socket pipes, bends, curves, junctions, traps, soil pans, &c., required by the local Board of Health, Birch End, for the purposes of drainage.

Interpretation.

In this specification, the words, "Local Board of Health," shall be understood to mean the Local Board of Health for the time being, duly elected and acting in and for the district of Birch End. The word "Engineer," shall mean Edward Ryde, of No. 14, Upper Belgrave Place, Eaton Square, London, Civil Engineer and Surveyor, or other the duly appointed Engineer or Surveyor to the said Local Board of Health, for the time being; and the word Contractor shall mean one or more Contractors, and shall include his or their heirs, executors, and administrators.

Extent of Contract.

This contract includes the manufacture and supply of all the straight and curved drain pipes, curve, bend, taper, and junction pieces, traps, soil pans, &c., required to construct and entirely complete the drainage of the town of Birch End, as the same are particularly delineated, and described upon the plans and drawings deposited in the offices of the Engineer, in London, and of the Clerk to the said Local Board of Health, at Birch End, and according to this specification.

Quality and description of pipes.

The ordinary pipes and pieces shall be of the description usually denominated "socket pipes," sound, well burnt, glazed stone ware, free from cracks, flaws, and all other imperfections, perfectly impermeable, truly cylindrical in the bore, straight in the axis, internally of their full specified diameter, with their inner and outer surfaces as nearly as possible concentric, and especial care must be taken that the sockets, which in the larger sizes of pipes exceeding nine inches internal diameter, shall be at least three inches in depth, will receive the smaller ends of the pipes.

The engineer shall be at liberty so often, and for so

Engineer has power to attend at Manufactory to inspect, &c.

long as he may think fit to attend at the manufactory, either by himself or his duly authorised clerk, for the purpose of inspecting the processes of the manufacture, and of ascertaining if his own instructions and this specification are properly attended to; and the contractor shall pay immediate attention to any directions he may think proper to make.

Length and dimensions of pipes, &c.

All pipes not exceeding six inches in diameter shall be made in lengths of two feet exclusive of the socket; beyond that diameter the length shall be three feet. The dimensions of the several pieces of bend pipe, curves, junctions, traps, and soil pans, are mentioned and described in the drawings, and should any discrepancy exist between the figured or written dimensions and the admeasurements by scale, the former are in all cases to be taken as the correct dimensions.

Soil Pans.

The soil pans must be of the shape delineated in the drawings, and the spreaders must be so adjusted as to keep the pans entirely clear of soil.

Times of delivery.

The whole of the pipes, bends, junctions, curves, traps, and soil pans, must be delivered at the railway station, Birch End, in such quantities and at such times as the engineer may from time to time direct; the whole of the contract to be finally completed and delivered on or before the 31st December next.

Engineer has power to make further tests, and to reject imperfect pipes.

The engineer shall be fully at liberty to make a further test of the pipes after their delivery, either as to their impermeability or strength or any other quality he may think fit, and if from any cause whatever he shall consider the pipes or other contrivances and things contained in this specification are not in his judgment of the best quality both in material and workmanship, according to the true intent and meaning of this specification, he shall be at liberty to reject the whole, or any part thereof, and the contractor shall immediately remove, at his own cost and charges, the pipes or pieces so rejected.

Samples of pipes, &c.

The contractor shall submit with his tender, samples of each description of pipes and pieces he intends to supply.

Contractor to find sureties.

The contractor shall, if required, find two good and competent sureties, who are willing to become bound in a penal sum equal in amount to one-fourth of the tender, for the due and complete performance of the contract.

The quantities of the several descriptions of pipes and

Quantities of pipes, etc., required.

pieces, so far as it is possible to ascertain, are stated in the schedule hereto annexed, and they are believed to be close approximations, but it is to be distinctly understood, that the engineer shall at all times have power to make any alterations in, additions to, or deductions from, the quantities so stated, which alterations in, additions to, or deductions from, shall not annul the contract, but an allowance shall be given or taken as the case may require; for the calculations of which allowance the schedule of prices shall be the basis.

Engineer shall determine doubts.

In the event of any doubt arising after the execution of the contract, as to the true intent or meaning of this specification, the said drawings therein referred to, or the said contract, the same shall be referred to the engineer, and his decision shall be conclusive and binding; any order or rule of court of law or equity to the contrary notwithstanding.

Times of payment.

And the said contractor shall be entitled to payment for his work, in manner following, viz., *i.e.*, 50 per cent. of the value of the pipes and pieces delivered from time to time, within one month of such delivery, and the remainder within two months of the final completion of the contract; the certificate of the engineer to the effect that the contractor is entitled to payment, being required in either case, before any money will be paid by the local board.

Tender for impermeable glazed stoneware, tubular socket, sewerage, and drain pipes, soil pans, &c.

_____ 1853.

To the Birch End Local Board of Health.

We, the undersigned contractors, hereby offer and agree to make and deliver at the railway station, at Birch End, impermeable glazed stoneware tubular socket pipes, half socket pipes, bends, curves, junctions, traps, soil pans, &c., in accordance with the terms and conditions of the annexed specification, and of the following schedule.

SCHEDULE.

Description.	Internal Diameter of each Pipe and Piece.	Probable quantities required.	Length of each Pipe exclusive of Socket.	Price per Foot.
Straight Pipes (Whole Sockets.)	3	500	2	
	4	650	2	
	5	1000	2	
	6	1150	2	
	9	2300	3	
	12	3800	3	
	15	1261	3	
Curved Pieces and Bends . .	3	12	2	
	4	16	2	
	5	23	2	
	6	25	2	
	9	40	3	
	12	60	3	
	15	10	3	
Straight Pipes (Half Sockets.)	6	22	2	
	9	46	3	
	12	76	3	
	15	30	3	
Taper Pieces . . .	3 to 4	10	2	
	4 „ 5	20	2	
	5 „ 6	30	2	
	6 „ 9	30	3	
	9 „ 12	30	3	
	12 „ 15	15	3	
Single Junction Pieces	Diameter of straight Piece.			
	3	5	2	
	4	10	2	
	5	20	2	
	6	20	2	
	9	30	3	
	12	30	3	
	15	30	3	
Double Junction Pieces	3	5	2	
	4	7	2	
	5	10	2	
	6	10	2	
	9	10	3	
	12	10	3	
	15	10	3	

Description.	Bore.	Number required.	Length.	Price each.
	Inches.			
Patent Syphon Traps .	2	50	2	
	3	50	2	
	4	50	2	
	6	50	2	
	9	50	3	
Patent Yard Syphons, with detached Grating, by which means they can be easily cleansed.	4	50		
	6	50		
	9	50		
	12	50		
Common Syphon Pans.		50		
Patent Syphon Pans . .		50		
Hopper Pans and Syphon Traps . .		50		
Gully Sinks, with Traps for Street Gratings	12	50		
	15	50		
	18	50		

And we will undertake to execute an agreement (to be prepared by and at the expense of the local board) for the due and complete fulfilment of all the conditions expressed and implied in and by the specification hereto annexed.

We are, Gentlemen,
Your obedient servants,
CONTRACTORS.

BIRCH END LOCAL BOARD OF HEALTH.

1853.

Contract, No. III.

PIPE LAYING.

Specification to be *observed* by the *Contractor* for laying and jointing water and drain pipes, for the Local Board of Health, Birch End, according to the instructions of Mr. Edward Ryde, the Engineer to the Local Board.

Interpretation. In this Specification the words "Local Board of Health" shall be understood to mean, the Local Board of Health duly elected, and acting in and for the district of Birch

End, and shall include themselves and their successors. The word "Engineer" shall mean Edward Ryde, of No. 14, Upper Belgrave Place, Eaton Square, London, Civil Engineer and Surveyor, or other, the duly appointed Engineer or Surveyor to the said Local Board of Health for the time being. The word "Contractor" shall mean one or more Contractors, and shall include his or their heirs, executors, or administrators.

Extent of Contract.

This contract includes the excavating for, and the laying and jointing of, all the water and drain pipes and other contrivances connected therewith, required to construct and completely finish the several sewers, drains, water mains, sub mains, &c., described and delineated upon the drawings prepared by the engineer; the taking up and subsequent replacement of the pavement, roadway, or surface soil, of whatever description; filling in and punning up the trenches; carting away the surplus earth; carting the pipes and pieces from the railway station at Birch End to the situations in which they will be required; lead and gasket for joints of water pipes, and clay or cement for joints of drain pipes; watching day and night to guard the public from accidents; the finding and providing of all and all manner of labour, and tools and materials (excepting only the pipes and pieces which will be delivered at the railway station by other contractors), necessary to the completion of the works to the entire satisfaction of the engineer.

Directions of Works and depths of cuttings.

The directions of the several sewers, drains, water mains, and sub mains, are respectively marked and delineated upon the plan, and the depths of cutting, and rates of inclination, are severally drawn upon the section, and marked in figures thereon. No deviation whatever from these drawings will be allowed, except by the express direction of the engineer, and should any descrepancies exist between the figured dimensions and the admeasurement by scale, the former are, in all cases, to be taken as the correct dimensions. The engineer will, at all times, set out and mark the several works upon the ground, and the contractor shall provide proper assistants, implements, and materials for that purpose, when called upon, from time to time, to do so.

Contractor to give notice to Surveyors of Highways before breaking up roads.

Before commencing to break up any public road, footway, or street, for the purposes of this contract, the contractor shall give all necessary notices to the surveyors of high ways, or other proper authorities, and shall pay any

fees that may be legally payable in respect of the same.

Excavations. The excavations of the specified depths shall be made in such lengths as the engineer may direct, and of sufficient widths, as shall, in the judgment of the engineer, enable the pipes to be properly laid and backed up. The bottom of the trench, for the larger sizes of drain pipes, shall be moulded to the shape of the pipe, and a notch shall be cut for the socket, so that the pipes may take a firm bearing and be securely bedded upon the foundation. The trench is, in all cases, to be an open cutting, as no tunnelling or benching will be allowed, excepting in cases of special emergency by express permission of the engineer. The sides of the cuttings are to be securely shored up where requisite, to prevent the adjacent earth from slipping or colting in, to protect the adjacent buildings, or to ensure the proper construction of the sewer. Where the foundations shall be unfit for the bedding of the pipes, the soft ground is to be taken out, and a proper and sound bedding, or foundation, substituted. If clay is met with in the excavations, so much of it is to be preserved as will be sufficient to make a layer of nine inches, at least, in thickness round all the sewers, so as to form an impermeable clay collar or casing to the same. The excavations are to be kept perfectly free from water during the progress of the work, the contractor providing all necessary apparatus for that purpose. The excavated earth is not to be thrown about in any direction most convenient to the navvies, but it is to be so placed as to cause as little interruption as possible with the free passage of the public, or annoyance to the adjacent inhabitants. When the line of sewer crosses through private property, none but unavoidable injury shall be done to the same, or the contractor shall be responsible.

Laying the drain pipes. The pipes shall be carted from the railway station, at the cost and expense of the contractor, and shall be stacked as conveniently as possible for use, without unnecessarily impeding the public highway.

The trench being opened to the satisfaction of the engigineer or his clerk of works, the pipes are to be properly and carefully fitted and matched, before they are taken into the trench. The pipe layer shall then be furnished with a bag stuffed with shavings or hay, of a size to fit the

pipe rather tightly, with a rope about ten yards in length, fastened at one end to the mouth of the bag.

The bag must be placed in the first pipe at the outfall, and the rope passed through each pipe as it is laid down, until the rope is served out; the joints are then to be made with clay of approved quality, and properly tempered, and left perfectly water tight. The bag is then to be drawn forward through all the pipes into the last pipe laid down, when other pipes are laid down until the rope from the bag has been again served out, when the joints are made as before. Curved, half socket, junction, and taper pieces are to be laid where directed. Neither the pipe layer, nor any other person, shall be allowed to walk over the pipes until they are covered over to an extent of at least nine inches.

Filling in. The pipes being laid, and the joints made to the satisfaction of the engineer, a layer of clay of nine inches thick is to be well punned in around the pipes, so as to form an impermeable casing of clay. The trench may be then filled in with the excavated earth up to the level of the bed for the water pipes, two men being constantly kept in the trench ramming to every man filling in.

Water pipes. The contractor to cart, at his own expense and cost, all the iron pipes and castings delivered at the railway station by another contractor to the respective positions in which they will be required, there to be stacked in places that may be least objectionable to the general public.

Pipe laying. Before the pipes are lowered into the trench, they are to be thoroughly cleaned out, so that no earth or rubbish may be contained in them. The joints are to be made sound, of lead and gaskett of approved quality; the depth of lead in the sockets to average two inches. No split or defective pipes or castings are on any account to be laid down, nor any screw cocks or hydrants to be fixed which leak or allow the water to pass by them; and should it be found that any such have been laid down or fixed, the contractor will have to take them out and substitute others at his own expense.

Hydrants and Screw Cocks. The contractor is to fix screw cocks and hydrants where indicated by the drawings or directed by the engineer; the hydrants to be connected with the main by two inch pipes. All branch pipes and dead ends are to be properly capped and left secure.

Gully Gratings, &c.

The contractor shall securely fix in brickwork set in hydraulic mortar, such gully gratings, sinks, fire plugs, and other contrivances as may be marked on the drawings, or directed by the engineer.

Remaining earth to be filled in.

The engineer being satisfied with the works that have been constructed, the remaining excavated earth, or so much thereof as may be required, shall be filled in in regular layers, not exceeding six inches in thickness, two men being kept ramming to every man filling in. If in the opinion of the engineer, the shoring and strutting timber cannot be removed from the deeper trenches with safety to the adjoining buildings, the same shall be left in the ground, and the contractor shall not be entitled to any extra payment on that account. Care is to be taken that all materials for re-forming the road are to be retained until the last, or until it becomes necessary to use them.

Pavements, Roads, etc. to be made good.

The pavement, roadway, or surface soil is to be made good, and left in as perfect a state as it was found to be previous to the commencement of the works, or as near thereto as may be, to the satisfaction of the engineer, his clerks, and assistants, and the surveyor of the highways, or other proper authorities.

Surplus earth.

The contractor is to cart away all surplus earth at his own expense, the same to be emptied into such open ditches or other places as the engineer may direct.

General Conditions.

Commencement and completion of works.

The contractor is to commence the several portions of the work immediately on an order being given by the engineer to that effect, and shall, on or before the 31st December next, complete the whole of the works herein specified, and such additional works as the engineer may direct to be executed.

Contractor to be present on works.

The contractor shall at all times be present on the works, or in his absence he shall provide a competent representative, fully authorized to act in his behalf in all matters relating to this contract.

Contractor to provide labour and materials, and to prevent accidents.

The contractor shall at all times, by day and by night, provide and use at his own cost all overlookers, labour, and materials of every description whatever, that may be required for proceeding with and completing the works contained in this contract in a workmanlike manner, or for preventing accidents, or affording accommodation to the

public during the progress of the said works, and shall in all cases immediately attend to the reasonable requirements of the engineer.

Minor parts included in contract.

Wherever neither the drawings nor specification contain any special notice of minor parts, the intention to include which is nevertheless to be inferred, and which parts are necessary for the completion and stability of the said works, all such additional parts are to be provided and performed by the contractor, and are supposed to be included in the sum at which he contracts for the works; and where any thing is directed to be done, or to "be provided if required," or words of similar import, it must be understood that every thing so referred to will be considered as included in the contractor's tender.

Descriptions not repeated are not invalidated.

It is to be distinctly understood, that though certain descriptions and stipulations are not repeated or implied in different parts of this specification, and in the contract to be entered into for the fulfilment of the same, it shall not be thence inferred that the remaining directions, descriptions, and stipulations, of which there shall be no repetition or amplification, are in anywise invalidated.

Contractor to proceed with works to satisfaction of engineer.

The contractor shall at all times proceed with the works at the rate of progress required by the engineer; and should the engineer be at any time dissatisfied with the nature or mode of proceeding in, or at the rate of progress of the work, or any part thereof, he shall have full power to procure and make use of all labour and materials which he may deem necessary, deducting the cost of such labour and materials from the money that may be due or become due to the contractor. But it is hereby expressly specified and declared, that the possession of this power by the engineer shall not in any degree relieve the contractor of his obligation to proceed in the execution of, and to complete the works with the required expedition.

Contract to be void if contractor fails to proceed with works to satisfaction of engineer.

Should the contractor fail to proceed with the works in the manner and at the rate of progress required by the superintending engineer, this contract shall be (at the option of the Local Board of Health, not otherwise) considered void, so far as relates to the work remaining to be done; and all sums of money that may be due to the contractor, together with the materials and implements in his possession, and all sums of money named as penalties for the non-fulfilment of the contract, shall be forfeited to the

Local Board, and the amount shall be considered as ascertained damages for breach of contract.

Engineer may direct alterations.

It is to be distinctly understood, that the engineer may at all times direct that there shall be made any alterations in, additions to, or deductions from, any of the works hereinbefore described or referred to; and which alterations in, additions to, or deductions from, shall not annul the contract, but the same shall be valued according to the schedule of prices, filled up by the contractor, and attached to his tender, and that the prices inserted in the schedule shall be considered as inclusive of all labourage, materials, and expenses connected with the work to which such prices apply.

Sureties.

The contractor shall (if so required) find two good and sufficient sureties in a penal sum, as nearly as may be equal to one-fourth the amount of the accepted tender, for the due performance of his contract.

Payments.

Payments to the extent of two-thirds of the value of the work executed will be made to the contractor upon the certificate of the engineer that the works have been executed in accordance with this specification, and to his satisfaction; one moiety of the remaining one-third will be paid to the contractor on the completion of the whole of the works contained in his contract, and the balance upon the expiration of six months, upon the certificate of the engineer that the whole of the work is in a satisfactory and proper state, and that no penalty under this specification has been incurred.

Contractor responsible for damage.

The contractor shall guarantee and hold harmless the Local Board of Health from any damage that may arise by reason of the negligence of his workpeople, or from any other cause, during the execution of this contract. And

Engineer to determine doubts.

should there be any doubt as to the meaning of any portion of this specification, the contractor tendering is requested to set forth the particulars of such doubt or obscurity in writing, and submit the same with his tender before the contract is signed; the question shall be discussed by the engineer and contractor, and if necessary, shall be formally settled in writing. After the execution of the contract, the decision of the engineer shall be conclusive and binding.

The Local Board do not bind themselves to accept the lowest or any tender.

BIRCH END LOCAL BOARD OF HEALTH.

Contract, No. III.

TENDER FOR PIPE LAYING.

_____ 1853.

To the Local Board of Health, Birch End.

Gentlemen,

I hereby propose, undertake, and agree to execute, perform, and do, the several works described in the foregoing specification, and in the drawings, according to the true, intent, and meaning thereof for the sum of pounds; and I also agree that the prices mentioned in the following schedule shall form the basis of a calculation for ascertaining the equivalent to be given or taken, in respect of any alterations in, additions to, or deductions from, the said works, that may be made from time to time, by order of the engineer.

I am, Gentlemen,

Your obedient servant,

CONTRACTOR.

Schedule of Prices before referred to.

	Price per foot lineal. £ s. d.
For laying stoneware drain pipes and pieces, including excavating, laying, jointing and filling in, punning ground, making good surface, carting away surplus earth, and every other expense in conformity with the specification.	
3 inches to 6 inches diameter 2 feet deep . .	
4 „ . .	
6 „ . .	
8 „ . .	
10 „ . .	
9 inches to 15 inches diameter 2 „ . .	
4 „ . .	
6 „ . .	
8 „ . .	
10 „ . .	
12 „ . .	
For fixing gully shoots and traps . . . each	
„ sink and yard gratings . . . „	

	£	s.	d.
For laying water pipes and pieces, including excavating, laying, jointing, filling in, and punning ground, and every other expense in conformity with the specification.			
3 inches diameter per lineal yard			
4 „ „			
5 „ „			
6 „ „			
7 „ „			
8 „ „			
9 „ „			
10 „ „			
11 „ „			
12 „ „			
For fixing stop cocks, including fixing and jointing, providing and fixing elm box over cock, and making good paving up to box.			
4 inches diameter each			
5 „			
6 „			
7 „			
8 „			
9 „			
10 „			
11 „			
12 „			
For fixing hydrants, including excavating, laying connecting pipes, and uniting the same to the mains, jointing, filling in and punning ground, and making good paving . . . each			

BIRCH END LOCAL BOARD OF HEALTH.

Contract, No. IV.

RESERVOIR.

Specification to be *observed* by the *Contractor* for the works set forth therein, required to be executed by contract, for the Local Board of Health, Birch End, according to the designs, drawings, and instructions of Mr. Edward Ryde, Civil Engineer and Surveyor.

Extent of Contract.—The works comprised in this contract, include the excavating for, and embanking and constructing a covered reservoir; the finding of all and all manner of materials, labour, tools, carriage, travelling expenses, and all other things of whatsoever description that may be required to carry on, erect, construct and completely finish such reservoir, as the same is particularly delineated and described in the several drawings, and in this specification.

Drawings.

Plate . . . Plan and Section of Reservoir.

Excavator. To excavate for the proposed reservoir to such depths as shown in the drawings, care being taken that the whole of the top soil or turf is to be removed and placed in a heap by itself, and to be used again in covering over the embankment and slopes of the said reservoir, when the same is constructed, and also that those soils which may be most retentive of water, may be placed as much as possible by themselves, to be used again on the embankment of the reservoir.

Embanking To embank the reservoir when constructed, with such of the excavated earths as the engineer may direct to be used for that purpose; the same to be executed in regular layers not exceeding six inches in thickness, and well punned, the proportion of punners, being such as the engineer may from time to time approve, but never less than three to one barrow load.

Capping the top of reservoir. To cap the top of the reservoir with the remaining excavated earths, regularly laid on in thin layers, well and solidly rammed over the arches before the removal of the centering. It is proposed to slope the embankments at an inclination of $1\frac{1}{2}$ to 1, that is the base, being one foot and a half to every foot of height. But if, during the execution of the work, the contractor should have reason to suppose that such rate of inclination will not ensure the stability of the embankment, the engineer is to be immediately apprised of his misgivings, and the contractor will be held responsible for all damage arising from slipping or any other cause.

Slopes to be $1\frac{1}{2}$ to 1.

Slopes to be trimmed and covered with turf. As the embankments advance and become consolidated, the slopes shall be carefully dressed or trimmed to the specified inclinations, and covered with the turf that was

removed from the site of the reservoir. This shall be done in the manner pasture lands are sometimes grafted; that is, the turf shall be laid on in slips, with an interval of uncovered ground between each slip, so that the turf taken off the horizontal surface, before the excavation for the reservoir, may by this means be made sufficient to cover with sward the increased surface of the reservoir and slopes, which shall then be sown with good and proper grass seeds.

Lining of puddle. To line with a coating of puddle at least nine inches in thickness the bottom of the reservoir; to line with a similar coating of puddle the space between the sides of the excavation and the brickwork, from the foundation upward, to about 1 foot 6 inches above the top water line, so that such lining may be about 9 inches thick at the top, 12 inches thick at the springing of the arches, and gradually increasing in width to the foundations, as shown on the drawings; to line thoroughly, with a similar coating of puddle, the whole of the excavations for the main and other pipes passing into and out of the reservoir, and extend the same a sufficient distance beyond the outside of the brickwork, the object being to seat the reservoir in an impermeable puddle basin.

Puddle. The puddle is to be made of pounded clay, of approved quality, well worked with water, cut, and rammed solid, and free from stones and rubbish. Great care is to be taken after it is placed, to preserve it from the effects of sun, air, wind cracks, or other flaws; and the contractor shall repair, at his own cost, all damage resulting from such causes.

Foundation of concrete. To form a foundation for the brickwork of the reservoir by spreading a layer of concrete, three inches in thickness on the top of the puddle, all over the bottom of the excavations forming the site of the intended reservoir.

Fill in spandrel of arches To fill in the spandrel of the arches to a height of 18 inches above the top water line, with concrete, before the centering is removed from the arches.

Clay. If sufficient clay for the puddle, should not be found in the excavations, concrete must be substituted in lieu of the puddle.

Concrete. The concrete must be compounded of gravel, perfectly clean and mixed with fresh well-burnt hydraulic lime of

approved quality, in the proportion of six parts of gravel to one of lime.

Gravel. The gravel to be perfectly clean and free from marl or loam, being a nice admixture of about two parts gravel to one part coarse sand. All stones in the gravel larger than about an inch and a half in diameter are to be broken.

Proportions of lime, gravel, and sand in concrete. The proportions of lime, gravel, and sand are to be accurately gauged. The lime is to be brought upon the ground fresh from the kiln, laid on a bed of gravel and sand not less than twelve inches thick, and spread over this to a depth of about 18 inches; and, while spreading, is to be slowly but continually sprinkled with clean water, from a rose headed watering pot, until the steaming has commenced, when the lime is to be covered up with gravel and sand so that no steam can escape, and to be left in that state until it is completely slaked and turns out an impalpable powder; the gravel and lime are then to be mixed in a dry state, to ensure their thorough incorporation, after which on a clean platform a proper proportion of clean water is to be added, the whole is to be turned over and well beaten, until a thorough admixture of all the parts is effected and brought to a tough consistency, when it is to be immediately filled into barrows, and teemed from a height of at least ten feet on to the place required, when it must be levelled at once to its proper thickness before it has time to set.

Barrow road. The contractor shall erect a proper barrow road or scaffold, from which the concrete can in all cases be teemed on to the place at which it is required.

Bricklayer.

Bricks. The bricks made use of throughout the work shall be hard, sound, well shapen, thoroughly burnt, and of uniform size, and shall be well saturated with water before being set.

Bats. No broken bats will be allowed to be used either externally or internally, unless absolutely necessary as closers.

Workmanship. The workmanship shall be of the best description. No joint of mortar shall exceed one quarter of an inch in thickness, and the work shall be laid in English bond.

Mortar. The mortar shall consist of fresh burnt lias lime of

approved quality and clean sharp sand, in the proportion of two parts sand, to one of unslacked Lime. They shall be intimately mixed in a dry state and well tempered with a proper quantity of water, and only mixed as required for use, the mortar that has previously set or become hard upon the ground shall not be permitted to be used in any part of the work.

Lime. When the lime is required to be slacked it shall be done with clean water, and covered up with sand so that no air slacked lime shall be used for any purpose whatever. No

Concrete foundations. brickwork is to be commenced on the concrete foundations until they have become hard and solid.

Brickwork. To build the pier, side, and end walls of reservoir in English bond, the whole of the joints to be flushed up solid with mortar, and in all walls of 18 inches thick and upwards, every third course shall be well grouted; the internal bricks of that course being properly floated in, and driven up one against another in the grouting so as to fill up all the interstices, and render the whole of the work a compact solid mass. The longitudinal pier and cross walls are to be well and properly bonded together, and the side and end walls must be battered and have piers, offsets, and step buttresses as shown in the drawings.

Skewbacks. The skewbacks of walls to be correctly worked to templates, and to be built with feather edge bricks made to shape, as no filling in with bits or pieces will be allowed.

Arches over Reservoir. The arches over the reservoir are to be composed of two four and a half inch rings; the whole of them are to be proceeded with at one time, and carried on as regularly as possible. The side and end arches must spring from the brickwork on a line forming a right angle with the batter face of the centre of the arch.

Soffits of Arches. To set close, and well flush up with mortar, the soffits of all the arches; and after the centring has been drawn, point the under side.

Groined Arch. To turn a groined arch in side wall for entrance into reservoir.

Centring. All centring, as may be requisite to turn all the arches of the reservoir, as well as all struts, close planking, and ribs necessary for carrying on the whole of the arches together in one breast, shall be found by the contractor. And no centring shall be removed until the whole of that set of arches has been properly keyed and backed with

the concrete spandrels, and the capping brought up as close as the work will permit.

Other Brickwork. To do all other brick work that may be required to complete the construction of the reservoir, according to the directions expressed or implied in the specification and drawings and to the satisfaction of the engineer.

Masonry. Cover the entrance to reservoir with three inch York flagging, and provide and fix tooled and rounded York stone treads and brick risers.

Perform any other masonry, necessary and requisite, for the completion of the work.

Carpenter's Work. Fit up the doorway at entrance with 1½ inch four paneled door; hang the same with a pair of 4 inch butts to 4½ by 3 inch rebated frame; and provide and fix a suitable lock and key.

Perform any other carpentry necessary to complete the works.

Painter's Work. Knot, stop, pumice, paint in four oils, grain oak and varnish the door, and door frame.

Smith's Work. Provide and fix a wrought iron step ladder as shown in drawing, and a wrought iron grating in York flagging over entrance.

TIME OF COMMENCEMENT AND COMPLETION.

Commencement and completion of Works. The works are to be commenced immediately on an order being given by the engineer and to be proceeded with at a rate of progress satisfactory to him—and to be finally completed within four months of the date of such order to commence, or the contractor shall forfeit £10 for every day that the work is delayed beyond the time specified, unless the engineer shall certify that the delay arises from any unavoidable or excusable cause.

Contractor to find materials; to be responsible for damage; and to keep work in repair for six months. The contractor is to provide all materials of every description and labour of every kind, that may be necessary to construct, and properly complete the work. He is to be responsible for all damage and accidents of every kind that may occur during the execution of the work and he is to keep the works in repair for six months, from the date of their completion.

Minor parts to be included, although not noticed in Specification. And wherever neither the drawings nor this specification contain any special notice of minor parts, the intention to include which is, nevertheless, to be inferred, and which parts are necessary for the completion and stability of the

works, all such additional parts are to be provided and performed by the contractor, and are supposed to be included in the sum at which he contracts for the works, and wherever any thing is directed to be done, or to be provided, if required, "or words of similar import," it must be understood that every thing so referred to will be considered as included in the contractor's tender.

Works to be executed to satisfaction of Engineer.

The whole of the works herein described, both as regards quality of materials and workmanship, shall be executed to the entire satisfaction of the engineer according to the true intent and meaning of the specification of which the engineer shall be the sole judge.

Engineer may direct alterations.

It is to be distinctly understood that the engineer may at all times direct, that there shall be made alterations in, additions to, or deductions from the works herein described or referred to; which said alterations in, additions to, or deductions from, shall not annul the contract, but an equivalent based upon the schedule of prices annexed to the contractor's tender shall be given or taken as the case may require.

Payments.

Payments to the extent of ninety per cent will be made monthly upon the value of the work executed provided the engineer shall certify that the work is proceeding to his satisfaction.

In one or other of the preceding specifications will be found the general stipulations usually contained in such documents.

CHAPTER XV.

TIMBER MEASURING.

TIMBER is computed at its solid contents, whether standing, rough, or hewn. Boards and planks are measured superficially. 40 feet of rough timber or 50 feet of hewn properly make a load, but in practice it is usual to consider 50 feet of timber, of any description, as a load. The reason assigned for the establishment of the different sizes of the load of rough and hewn timber is, that the former being measured in a round state (as will be presently shown) by taking one-fourth of the circumference as the side of equal square produces a result one-fifth short of the actual solid

content, while squared or hewn timber is measured upon more accurate mathematical principles.

In treating the subject of measuring solid timber, it is necessary to premise that the rules about to be given are such as have become customary in practice, and not those which a mathematician would apply to the operation. The true mathematical solid content of any piece of timber may be found by the application of one or more of the rules contained in the mensuration of solids in a former part of this work, but such a content would not be in accordance with customary usages, and consequently but of little value to the practical man, while the mode of its attainment would also be tedious and complex.

In measuring standing timber, the first thing to be estimated approximately is the height of the tree. This is done by holding a 20-feet rod as high up the tree as a man can reach, and by guessing the remainder, which may generally be very nicely done; for supposing the bottom of the rod to be held 6 feet from the ground, 26 feet up the tree is actually measured, and the proportion which the unmeasured height bears to the measured will become tolerably apparent to the eye. I have heard of a ladder being carried about with which to measure the heights of the trees, but never saw it done. What is called the *lop* and *top* of the tree is measured or estimated separately, as it generally carries a less price. Up to 24 inches circumference or 6 inches quarter girt is generally taken as timber, and all below that size goes as "lop and top;" but the exact minimum of the timber and maximum of "lop and top" is made the subject of agreement between the "surveyors for buyer and seller" before they commence their work.

The method of taking the "girt" of a tree and allowing for bark is also (in many cases) the subject of agreement between the "surveyors." It is in some localities (but we will hope very few) customary for the purchaser's surveyor to insist that the girting line be first divided into three parts, and that one-third of the circumference be entirely thrown out as an allowance for bark, the remaining two-thirds only to be divided into four for the "quarter girt."

Another custom allows the "purchasing surveyor" to girt the tree where he pleases between the middle and bottom part.

A third insists that, let the tree taper however irregularly, the girt shall be taken exactly half-way up the tree.

But these and all similar customs are so obviously uncertain in the results they produce, that no surveyor of common ability or integrity will agree to adopt them. The simple business-like way is to ascertain as nearly as possible the fair average quarter girt,

or one-fourth part of the circumference, and to make therein such an allowance as may be fairly estimated to reduce it to what it would have been had the tree been without bark. This allowance in the quarter girt for bark may be very fairly reduced to an agreed standard. Up to a given figure in quarter girt, the allowance to be one inch; beyond that, and up to some other size, an inch and a half; and so on. The description of tree will of course have great weight in arranging this standard. Oak trees, in which the quarter girt is 12 inches, may require 1 inch allowance thereout for bark, while in the case of ash, elm, and beech, half an inch may in some cases be sufficient.

A mathematically educated surveyor will of course readily ascertain the correct allowance to be made for bark by guaging its approximate thickness, and deducting twice that thickness from the calculated diameter of the tree, including bark, and he will then have the actual diameter without the bark. This being reduced to circumference and divided by 4, the actual quarter girt of the timber may be placed in comparison with the quarter girt of the tree, and the true allowance for bark will be their difference. A calculation of this kind applied to about three sizes of trees will form the basis of an arrangement which may be fairly adopted in the manner I have previously suggested.

The average quarter girt of a standing tree that tapers with tolerable regularity may be ascertained by girting it at the bottom, and taking the mean between the quarter girt there and the six inches, or whatever may be agreed on as the minimum quarter girt at which the timber of the first quality is to cease, and the "lop and top" to commence. The point at which the tree will girt 24 inches in circumference is of no importance in taking the quarter girts, but it requires the exercise of the surveyor's judgment in ascertaining the heights. It is well for the sake of accuracy that it is not so, as an error in the girt would enter into the whole calculation of the tree, while an error in length is confined to the extent of the error itself.

Where the tree does not taper regularly, various expediences must be adopted to ascertain the average girt. It is impossible to lay down rules that may produce approximate results in every case; the exercise of a very little ingenuity will overcome most of them. When a tree continues up to a certain height, nearly the same size, and then tapers, it will be best to measure the two parts separately. The girt of these two parts may be very often obtained in this way, suppose the lower part to be 14 feet high, take the quarter girt at 7 feet, which suppose to be 30 inches, this will be the mean of

the lower part; take the quarter girt at the bottom of the tree, which suppose 35 inches, which being 5 inches greater than the quarter girt at 7 feet high, we may consider the quarter girt at that point is 5 inches greater than at 14 feet high; hence we have 25 inches, to average with 6 inches, for the mean quarter girt of the upper part of the tree.

In measuring round timber that has been felled, the length can be accurately taken, and the girt as often as required to obtain a correct average, bearing in mind, that when the girt is taken several times, it should always be at equidistant points. To illustrate this, let fig. 196 be the section of a piece of timber 25 feet long, and of the respective quarter girts as figured. Incompetent measurers would take the girt at about three places, namely at B which they would suppose to represent the girt of the length A B C; at D, and at F, and would average them in this way:

Quarter girt	at	B	20
„ „	at	D	14
„ „	at	F	10
		3)	44
Mean quarter girt			14½

Now let us see the correct result of averaging the quarter girts, taken at equidistant points.

Quarter girt	at	A	20
„ „	at	B	20
„ „	at	C	20
„ „	at	D	14
„ „	at	E	15
„ „	at	F	10
		6)	99
Correct average quarter girt			16½

The content of a piece of timber 25 feet long by 14½ inches quarter girt is	36 ft. 6 in.
The same length, but 16½ inches quarter, girt is . .	47 „ 3 „
Loss by the incorrect method of taking the dimensions	10 ft. 9 in.

Practical timber surveyors generally have a tape or strap for taking the girt of trees, marked to inches, but numbered only at every fourth division; that is, at 4 inches it is numbered 1; at 8, 2; at 12, 3, and so on; by which simple arrangement, the quarter girt in inches and quarters is shown at once.

Squared timber is measured by taking the length, breadth, and

thickness. The length and breadth are reduced to the side of equal square, which is then treated as the quarter girt. It is very customary to add the breadth to the thickness, and take half for the side of equal square, but such a custom is very erroneous, and a Table has been added to obviate it.

The superficial content of planks is found, by multiplying the length, in feet and inches, by the widths; attention is required in taking the widths of irregular planks, to do so at equidistant points, as explained in the girting of irregular timber.

Explanation of Table No. 1.

Table of solid measure.

Each page of this table is divided into two parts, and each part into five columns. At the head of each part, is set forth the length in feet; and in the first column of each part is the quarter girt or side of equal square in inches. In the second column of each part is the solid content in feet and inches, of the piece of timber (or any cube) whose length is equal to the length set forth at the head of the table; and whose quarter girt, or side of square, is equal to the one expressed in column 1, opposite to the cubic content in column 2.

In columns 3, 4, and 5, are contained the contents of solids, corresponding to the same length; but whose respective quarter girts are increased by the fractional parts of an inch, which are severally denoted at the heads of such columns.

Ex. 1.—What is the content of the standing tree (according to the customary method of treating one-fourth of the circumference, or quarter girt, as the side of equal square), whose height is 39 feet, and average quarter girt 40 inches.

In the section of the table headed 39 feet, and in column 2, opposite 40 inches in column 1, stands 433 ft. 4 in., the required content of the tree.

Ex. 2—Required the content of the piece of timber whose length is 20 feet and quarter girt 16¼ inches.

In the section of the table headed 20 feet long, opposite 16 inches quarter girt, and in the column headed ¼ inch, stands 36 feet 8 inches, the required content.

Ex. 3.—Required the content of the tree, 15 feet long and 20½ inches quarter girt.

In the table headed 15 feet long, opposite 20 inches quarter girt, and in the column headed ½ inch, stands 43 feet 9 inches, cubic content.

Quarter Girt.	1 foot long.								Quarter Girt.	2 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft	in.	ft.	in.	ft.	in.	ft.	in.
1		0		0		0		0	1		0		0		0		0
2		0		0		0		1	2		1		1		1		1
3		1		1		1		1	3		1		2		2		2
4		1		1		2		2	4		3		3		3		4
5		**2**		**2**		**2**		**3**	**5**		**4**		**5**		**5**		**5**
6		3		3		3		4	6		6		6		7		8
7		4		4		5		5	7		8		9		9		10
8		5		6		6		6	8		11		11	1	0	1	1
9		7		7		7		8	9	1	1	1	2	1	3	1	4
10		**8**		**9**		**9**		**10**	**10**	**1**	**5**	**1**	**5**	**1**	**6**	**1**	**7**
11		10		10		11		11	11	1	8	1	9	1	10	1	11
12	1	0	1	0	1	1	1	1	12	2	0	2	1	2	2	2	3
13	1	2	1	3	1	3	1	4	13	2	4	2	5	2	6	2	7
14	1	4	1	5	1	5	1	6	14	2	9	2	10	2	11	3	0
15	**1**	**7**	**1**	**7**	**1**	**8**	**1**	**9**	**15**	**3**	**1**	**3**	**3**	**3**	**4**	**3**	**5**
16	1	9	1	10	1	11	1	11	16	3	7	3	8	3	9	3	11
17	2	0	2	1	2	1	2	2	17	4	0	4	2	4	3	4	4
18	2	3	2	4	2	4	2	5	18	4	6	4	7	4	9	4	10
19	2	6	2	7	2	8	2	8	19	5	0	5	2	5	3	5	5
20	**2**	**9**	**2**	**10**	**2**	**11**	**3**	**0**	**20**	**5**	**7**	**5**	**8**	**5**	**10**	**6**	**0**
21	3	1	3	2	3	2	3	3	21	6	1	6	3	6	5	6	7
22	3	4	3	5	3	6	3	7	22	6	9	6	10	7	0	7	2
23	3	8	3	9	3	10	3	11	23	7	4	7	6	7	8	7	10
24	4	0	4	1	4	2	4	3	24	8	0	8	2	8	4	8	6
25	**4**	**4**	**4**	**5**	**4**	**6**	**4**	**7**	**25**	**8**	**8**	**8**	**10**	**9**	**0**	**9**	**2**
26	4	8	4	9	4	10	5	0	26	9	5	9	7	9	9	9	11
27	5	1	5	2	5	3	5	4	27	10	1	10	4	10	6	10	8
28	5	5	5	6	5	8	5	9	28	10	11	11	1	11	3	11	6
29	5	10	5	11	6	0	6	2	29	11	8	11	11	12	1	12	3
30	**6**	**3**	**6**	**4**	**6**	**5**	**6**	**7**	**30**	**12**	**6**	**12**	**8**	**12**	**11**	**13**	**2**
31	6	8	6	9	6	11	7	0	31	13	4	13	7	13	9	14	0
32	7	1	7	3	7	4	7	5	32	14	3	14	5	14	8	14	11
33	7	7	7	8	7	9	7	11	33	15	1	15	4	15	7	15	10
34	8	0	8	2	8	3	8	4	34	16	1	16	3	16	6	16	9
35	**8**	**6**	**8**	**7**	**8**	**9**	**8**	**10**	**35**	**17**	**0**	**17**	**3**	**17**	**6**	**17**	**9**
36	9	0	9	1	9	3	9	4	36	18	0	18	3	18	6	18	9
37	9	6	9	8	9	9	9	11	37	19	0	19	3	19	6	19	9
38	10	0	10	2	10	3	10	5	38	20	1	20	4	20	7	20	10
39	10	7	10	8	10	10	11	0	39	21	1	21	5	21	8	21	11
40	**11**	**1**	**11**	**3**	**11**	**5**	**11**	**6**	**40**	**22**	**3**	**22**	**6**	**22**	**9**	**23**	**1**
41	11	8	11	10	11	11	12	1	41	23	4	23	8	23	11	24	2
42	12	3	12	5	12	6	12	8	42	24	6	24	9	25	1	25	5
43	12	10	13	0	13	2	13	3	43	25	8	26	0	26	3	26	7
44	13	5	13	7	13	9	13	11	44	26	11	27	2	27	6	27	10
45	**14**	**1**	**14**	**3**	**14**	**4**	**14**	**6**	**45**	**28**	**1**	**28**	**5**	**28**	**9**	**29**	**1**
46	14	8	14	10	15	0	15	2	46	29	5	29	8	30	0	30	4
47	15	4	15	6	15	8	15	10	47	30	8	31	0	31	4	31	8
48	16	0	16	2	16	4	16	6	48	32	0	32	4	32	8	33	0
49	16	8	16	10	17	0	17	2	49	33	4	33	8	34	0	34	4
50	**17**	**4**	**17**	**6**	**17**	**8**	**17**	**11**	**50**	**34**	**9**	**35**	**1**	**35**	**5**	**35**	**9**

Quarter Girt.	3 feet long.								Quarter Girt.	4 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		1		1		1		2	2		1		2		2		2
3		2		3		3		3	3		3		3		4		5
4		4		4		5		6	4		5		6		7		7
5		**6**		**7**		**7**		**8**	**5**		**8**		**9**		**10**		**11**
6		9		10		10		11	6	1	0	1	1	1	2	1	3
7	1	0	1	1	1	2	1	3	7	1	4	1	5	1	7	1	8
8	1	4	1	5	1	6	1	7	8	1	9	1	11	2	0	2	1
9	1	8	1	9	1	10	2	0	9	2	3	2	4	2	6	2	8
10	**2**	**1**	**2**	**2**	**2**	**3**	**2**	**5**	**10**	**2**	**9**	**2**	**11**	**3**	**1**	**3**	**2**
11	2	6	2	8	2	9	2	10	11	3	4	3	6	3	8	3	10
12	3	0	3	1	3	3	3	5	12	4	0	4	2	4	4	4	6
13	3	6	3	8	3	9	3	11	13	4	8	4	10	5	0	5	3
14	4	1	4	3	4	4	4	6	14	5	5	5	8	5	10	6	0
15	**4**	**8**	**4**	**10**	**5**	**0**	**5**	**2**	**15**	**6**	**3**	**6**	**5**	**6**	**8**	**6**	**10**
16	5	4	5	6	5	8	5	10	16	7	1	7	4	7	7	7	9
17	6	0	6	2	6	4	6	7	17	8	0	8	3	8	6	8	9
18	6	9	6	11	7	1	7	4	18	9	0	9	3	9	6	9	9
19	7	6	7	9	7	11	8	1	19	10	0	10	3	10	7	10	10
20	**8**	**4**	**8**	**6**	**8**	**9**	**9**	**0**	**20**	**11**	**1**	**11**	**5**	**11**	**8**	**11**	**11**
21	9	2	9	5	9	8	9	10	21	12	3	12	6	12	10	13	2
22	10	1	10	4	10	6	10	9	22	13	5	13	9	14	1	14	4
23	11	0	11	3	11	6	11	9	23	14	8	15	0	15	4	15	8
24	12	0	12	3	12	6	12	9	24	16	0	16	4	16	8	17	0
25	**13**	**0**	**13**	**3**	**13**	**6**	**13**	**10**	**25**	**17**	**4**	**17**	**8**	**18**	**1**	**18**	**5**
26	14	1	14	4	14	7	14	11	26	18	9	19	2	19	6	19	10
27	15	2	15	6	15	9	16	0	27	20	3	20	7	21	0	21	5
28	16	4	16	7	16	11	17	3	28	21	9	22	2	22	7	22	11
29	17	6	17	10	18	1	18	5	29	23	4	23	9	24	2	24	7
30	**18**	**9**	**19**	**1**	**19**	**4**	**19**	**8**	**30**	**25**	**0**	**25**	**5**	**25**	**10**	**26**	**3**
31	20	0	20	4	20	8	21	0	31	26	8	27	1	27	7	28	0
32	21	4	21	8	22	0	22	4	32	28	5	28	11	29	4	29	9
33	22	8	23	0	23	4	23	9	33	30	3	30	8	31	2	31	8
34	24	1	24	5	24	9	25	2	34	32	1	32	7	33	1	33	6
35	**25**	**6**	**25**	**11**	**26**	**3**	**26**	**7**	**35**	**34**	**0**	**34**	**6**	**35**	**0**	**35**	**6**
36	27	0	27	4	27	9	28	2	36	36	0	36	6	37	0	37	6
37	28	6	28	11	29	3	29	8	37	38	0	38	6	39	1	39	7
38	30	1	30	6	30	10	31	3	38	40	1	40	7	41	2	41	8
39	31	8	32	1	32	6	32	11	39	42	3	42	9	43	4	43	11
40	**33**	**4**	**33**	**9**	**34**	**2**	**34**	**7**	**40**	**44**	**5**	**45**	**0**	**45**	**7**	**46**	**1**
41	35	0	35	5	35	10	36	4	41	46	8	47	3	47	10	48	5
42	36	9	37	2	37	7	38	1	42	49	0	49	7	50	2	50	9
43	38	6	38	11	39	5	39	10	43	51	4	51	11	52	7	53	2
44	40	4	40	9	41	3	41	9	44	53	9	54	5	55	0	55	7
45	**42**	**2**	**42**	**8**	**43**	**1**	**43**	**7**	**45**	**56**	**3**	**56**	**10**	**57**	**6**	**58**	**2**
46	44	1	44	7	45	0	45	6	46	58	9	59	5	60	1	60	8
47	46	0	46	6	47	0	47	6	47	61	4	62	0	62	8	63	4
48	48	0	48	6	49	0	49	6	48	64	0	64	8	65	4	66	6
49	50	0	50	6	51	0	51	7	49	66	8	67	4	68	0	68	9
50	**52**	**1**	**52**	**7**	**53**	**1**	**53**	**8**	**50**	**69**	**5**	**70**	**2**	**70**	**10**	**71**	**6**

Quarter Girt.	5 feet long.								Quarter Girt.	6 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		2		2		3		3	2		2		2		3		4
3		4		4		5		6	3		4		5		6		7
4		7		7		8		9	4		8		9		0		11
5		**10**		**11**	**1**	**1**	**1**	**2**	**5**	**1**	**0**	**1**	**2**	**1**	**3**	**1**	**4**
6	1	3	1	4	1	6	1	7	6	1	6	1	7	1	9	1	11
7	1	8	1	10	1	11	2	1	7	2	0	2	2	2	4	2	6
8	2	3	2	4	2	6	2	8	8	2	8	2	10	3	0	3	2
9	2	10	3	0	3	2	3	4	9	3	4	3	7	3	9	3	11
10	**3**	**6**	**3**	**8**	**3**	**10**	**4**	**0**	**10**	**4**	**2**	**4**	**4**	**4**	**7**	**4**	**10**
11	4	2	4	5	4	7	4	9	11	5	0	5	3	5	6	5	9
12	5	0	5	2	5	5	5	8	12	6	0	6	3	6	6	6	9
13	5	10	6	1	6	4	6	7	13	7	0	7	4	7	7	7	10
14	6	10	7	0	7	3	7	6	14	8	2	8	5	8	9	9	1
15	**7**	**10**	**8**	**1**	**8**	**4**	**8**	**7**	**15**	**9**	**4**	**9**	**8**	**10**	**0**	**10**	**4**
16	8	11	9	2	9	5	9	9	16	10	8	11	0	11	4	11	8
17	10	0	10	4	10	8	10	11	17	12	0	12	5	12	9	13	1
18	11	3	11	7	11	11	12	2	18	13	6	13	10	14	3	14	8
19	12	6	12	10	13	2	13	6	19	15	0	15	5	15	10	16	3
20	**13**	**11**	**14**	**3**	**14**	**7**	**14**	**11**	**20**	**16**	**8**	**17**	**1**	**17**	**6**	**17**	**11**
21	15	4	15	8	16	1	16	5	21	18	4	18	10	19	3	19	8
22	16	10	17	2	17	7	18	0	22	20	2	20	7	21	1	21	7
23	18	4	18	9	19	2	19	7	23	22	0	22	6	23	0	23	6
24	20	0	20	5	20	10	21	3	24	24	0	24	6	25	0	25	6
25	**21**	**8**	**22**	**2**	**22**	**7**	**23**	**0**	**25**	**26**	**0**	**26**	**7**	**27**	**1**	**27**	**7**
26	23	6	23	11	24	5	24	10	26	28	2	28	8	29	3	29	10
27	25	4	25	9	26	3	26	9	27	30	4	30	11	31	6	32	1
28	27	3	27	8	28	2	28	8	28	32	8	33	3	33	10	34	5
29	29	2	29	8	30	3	30	9	29	35	0	35	8	36	3	36	10
30	**31**	**3**	**31**	**9**	**32**	**4**	**32**	**10**	**30**	**37**	**6**	**38**	**1**	**38**	**9**	**39**	**5**
31	33	4	33	10	34	5	35	0	31	40	0	40	8	41	4	42	0
32	35	7	36	1	36	8	37	3	32	42	8	43	4	44	0	44	8
33	37	10	38	5	39	0	39	7	33	45	4	46	1	46	9	47	5
34	40	2	40	9	41	4	41	11	34	48	2	48	10	49	7	50	4
35	**42**	**6**	**43**	**2**	**43**	**9**	**44**	**4**	**35**	**51**	**0**	**51**	**9**	**52**	**6**	**53**	**3**
36	45	0	45	7	46	3	46	10	36	54	0	54	9	55	6	56	3
37	47	6	48	2	48	10	49	6	37	57	0	57	10	58	7	59	4
38	50	2	50	10	51	5	52	2	38	60	2	60	11	61	9	62	7
39	52	10	53	6	54	2	54	10	39	63	4	64	2	65	0	65	10
40	**55**	**7**	**56**	**3**	**56**	**11**	**57**	**8**	**40**	**66**	**8**	**67**	**6**	**68**	**4**	**69**	**2**
41	58	4	59	1	59	10	60	6	41	70	0	70	11	71	9	72	7
42	61	3	61	11	62	9	63	5	42	73	6	74	4	75	3	76	2
43	64	2	64	11	65	8	66	5	43	77	0	77	11	78	10	79	9
44	67	3	68	0	68	9	69	6	44	80	8	81	7	82	6	83	5
45	**70**	**4**	**71**	**1**	**71**	**11**	**72**	**8**	**45**	**84**	**4**	**85**	**4**	**86**	**3**	**87**	**2**
46	73	6	74	3	75	1	75	11	46	88	2	89	1	90	1	91	0
47	76	8	77	6	78	4	79	2	47	92	0	93	0	94	0	95	0
48	80	0	80	10	81	8	82	6	48	96	0	97		98	0	99	0
49	83	4	84	3	85	1	85	11	49	100	0	101	1	102	1	103	1
50	**86**	**10**	**87**	**8**	**88**	**7**	**89**	**5**	**50**	**104**	**2**	**105**	**2**	**106**	**3**	**107**	**4**

Quarter Girt.	7 feet long.								Quarter Girt.	8 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		2		3		4		4	2		3		3		4		5
3		5		6		7		8	3		6		7		8		9
4		9		10	1	0	1	1	4		11	1	0	1	1	1	3
5	**1**	**3**	**1**	**4**	**1**	**6**	**1**	**7**	**5**	**1**	**5**	**1**	**6**	**1**	**8**	**1**	**10**
6	1	9	1	11	2	1	2	2	6	2	0	2	2	2	4	2	6
7	2	5	2	7	2	9	2	11	7	2	9	2	11	3	1	3	4
8	3	1	3	4	3	6	3	9	8	3	7	3	9	4	0	4	3
9	3	11	4	2	4	5	4	7	9	4	6	4	9	5	0	5	3
10	**4**	**10**	**5**	**1**	**5**	**4**	**5**	**7**	**10**	**5**	**7**	**5**	**10**	**6**	**1**	**6**	**5**
11	5	10	6	2	6	5	6	8	11	6	9	7	0	7	4	7	8
12	7	0	7	3	7	7	7	11	12	8	0	8	4	8	8	9	0
13	8	3	8	6	8	10	9	2	13	9	5	9	9	10	1	10	6
14	9	6	9	10	10	2	10	7	14	10	11	11	3	11	8	12	1
15	**10**	**11**	**11**	**4**	**11**	**8**	**12**	**1**	**15**	**12**	**6**	**12**	**11**	**13**	**4**	**13**	**9**
16	12	5	12	10	13	3	13	8	16	14	2	14	8	15	1	15	7
17	14	1	14	5	14	11	15	4	17	16	1	16	6	17	0	17	6
18	15	9	16	2	16	8	17	1	18	18	0	18	6	19	0	19	6
19	17	7	18	0	18	6	18	11	19	20	1	20	7	21	1	21	8
20	**19**	**5**	**19**	**11**	**20**	**5**	**20**	**11**	**20**	**22**	**3**	**22**	**9**	**23**	**4**	**23**	**11**
21	21	5	21	11	22	5	23	0	21	24	6	25	1	25	8	26	5
22	23	6	24	1	24	7	25	2	22	26	11	27	6	28	1	28	9
23	25	9	26	3	26	10	27	5	23	29	5	30	0	30	8	31	4
24	28	0	28	7	29	2	29	9	24	32	0	32	8	33	4	34	0
25	**30**	**5**	**31**	**0**	**31**	**7**	**32**	**3**	**25**	**34**	**9**	**35**	**5**	**36**	**1**	**36**	**10**
26	32	10	33	6	34	2	34	9	26	37	7	38	3	39	0	39	9
27	35	5	36	1	36	9	37	5	27	40	6	41	3	42	0	42	9
28	38	1	38	9	39	6	40	2	28	43	7	44	4	45	1	45	11
29	40	11	41	7	42	4	43	0	29	46	9	47	6	48	4	49	2
30	**43**	**9**	**44**	**6**	**45**	**3**	**45**	**11**	**30**	**50**	**0**	**50**	**10**	**51**	**8**	**52**	**6**
31	46	9	47	6	48	3	49	0	31	53	5	54	3	55	2	56	0
32	49	9	50	7	51	4	52	2	32	56	11	57	9	58	9	59	7
33	52	11	53	9	54	7	55	4	33	60	6	61	5	62	4	63	3
34	56	2	57	0	57	10	58	8	34	64	3	65	2	66	1	67	1
35	**59**	**7**	**60**	**5**	**61**	**3**	**62**	**1**	**35**	**68**	**1**	**69**	**0**	**70**	**0**	**71**	**0**
36	63	0	63	10	64	9	65	8	36	72	0	73	0	74	0	75	0
37	66	7	67	5	68	4	69	3	37	76	1	77	1	78	1	79	2
38	70	2	71	1	72	0	73	0	38	80	2	81	3	82	4	83	5
39	73	11	74	10	75	10	76	10	39	84	6	85	7	86	8	87	9
40	**77**	**9**	**78**	**9**	**79**	**9**	**80**	**9**	**40**	**88**	**10**	**90**	**0**	**91**	**1**	**92**	**3**
41	81	9	82	9	83	9	84	9	41	93	5	94	6	95	8	96	10
42	85	9	86	9	87	10	88	10	42	98	0	99	1	100	4	101	6
43	89	11	90	11	92	0	93	0	43	102	9	103	11	105	1	106	4
44	94	1	95	2	96	3	97	4	44	107	7	108	9	110	0	111	3
45	**98**	**5**	**99**	**6**	**100**	**8**	**101**	**9**	**45**	**112**	**6**	**113**	**9**	**115**	**0**	**116**	**3**
46	102	10	104	0	105	1	106	3	46	117	7	118	10	120	1	121	5
47	107	5	108	6	109	8	110	10	47	122	9	124	0	125	4	126	8
48	112	0	113	2	114	4	115	6	48	128	0	129	4	130	8	132	0
49	116	9	117	11	119	1	120	4	49	133	5	134	9	136	1	137	6
50	**121**	**6**	**122**	**9**	**124**	**0**	**125**	**2**	**50**	**138**	**11**	**140**	**3**	**141**	**8**	**143**	**1**

Quarter Girt.	9 feet long.								Quarter Girt.	10 feet long.							
			¼		½		¾					¼		½		¾	
Inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	Inches	ft.	in.	ft.	in.	ft	in.	ft.	in.
2		3		4		5		6	2		3		4		5		6
3		7		8		9		10	3		7		9		10	1	0
4	1	0	1	1	1	2	1	5	4	1	1	1	3	1	5	1	7
5	**1**	**7**	**1**	**9**	**1**	**11**	**2**	**1**	**5**	**1**	**9**	**1**	**11**	**2**	**1**	**2**	**3**
6	2	3	2	5	2	8	2	10	6	2	6	2	8	2	11	3	2
7	3	1	3	3	3	6	3	9	7	3	5	3	8	3	11	4	2
8	4	0	4	3	4	6	4	9	8	4	5	4	9	5	0	5	4
9	5	1	5	4	5	8	5	11	9	5	7	5	11	6	3	6	7
10	**6**	**3**	**6**	**7**	**6**	**11**	**7**	**3**	**10**	**6**	**11**	**7**	**3**	**7**	**8**	**8**	**0**
11	7	7	7	11	8	3	8	7	11	8	5	8	9	9	2	9	7
12	9	0	9	4	9	9	10	2	12	10	0	10	5	10	10	11	3
13	10	7	11	0	11	5	11	10	13	11	9	12	2	12	8	13	1
14	12	3	12	8	13	2	13	7	14	13	7	14	1	14	7	15	1
15	**14**	**1**	**14**	**6**	**15**	**0**	**15**	**6**	**15**	**15**	**7**	**16**	**2**	**16**	**8**	**17**	**3**
16	16	0	16	6	17	0	17	6	16	17	9	18	4	18	11	19	6
17	18	1	18	7	19	2	19	8	17	20	1	20	8	21	3	21	10
18	20	3	20	10	21	5	22	0	18	22	6	23	1	23	9	24	5
19	22	7	23	2	23	9	24	4	19	25	1	25	9	26	5	27	1
20	**25**	**0**	**25**	**7**	**26**	**3**	**26**	**11**	**20**	**27**	**9**	**28**	**6**	**29**	**2**	**29**	**11**
21	27	7	28	3	28	11	29	7	21	30	7	31	4	32	1	32	10
22	30	3	30	11	31	8	32	4	22	33	7	34	4	35	2	35	11
23	33	1	33	9	34	6	35	3	23	36	9	37	6	38	4	39	2
24	36	0	36	9	37	6	38	3	24	40	0	40	10	41	8	42	6
25	**39**	**1**	**39**	**10**	**40**	**8**	**41**	**5**	**25**	**43**	**5**	**44**	**3**	**45**	**2**	**46**	**0**
26	42	3	43	1	43	11	44	9	26	46	11	47	10	48	9	49	8
27	45	7	46	5	47	3	48	1	27	50	7	51	7	52	6	53	6
28	49	0	49	10	50	9	51	8	28	54	5	55	5	56	5	57	5
29	52	7	53	6	54	5	55	4	29	58	5	59	5	60	5	61	5
30	**56**	**3**	**57**	**2**	**58**	**2**	**59**	**1**	**30**	**62**	**6**	**63**	**6**	**64**	**7**	**65**	**8**
31	60	1	61	0	62	0	63	0	31	66	9	67	10	68	11	70	0
32	64	0	65	0	66	0	67	0	32	71	1	72	3	73	4	74	6
33	68	1	69	1	70	2	71	2	33	75	7	76	9	77	11	79	1
34	72	3	73	4	74	5	75	6	34	80	3	81	5	82	8	83	10
35	**76**	**7**	**77**	**8**	**78**	**9**	**79**	**10**	**35**	**85**	**1**	**86**	**3**	**87**	**6**	**88**	**9**
36	81	0	82	1	83	3	84	5	36	90	0	91	3	92	6	93	9
37	85	7	86	9	87	11	89	1	37	95	1	96	4	97	8	98	11
38	90	3	91	5	92	8	93	10	38	100	3	101	7	102	11	104	3
39	95	1	96	3	97	6	98	9	39	105	7	106	11	108	4	109	9
40	**100**	**0**	**101**	**3**	**102**	**6**	**103**	**9**	**40**	**111**	**1**	**112**	**6**	**113**	**11**	**115**	**4**
41	105	1	106	4	107	8	108	11	41	116	9	118	2	119	7	121	0
42	110	3	111	6	112	11	114	3	42	122	6	123	11	125	5	126	11
43	115	7	116	11	118	3	119	7	43	128	5	129	11	131	5	132	11
44	121	0	122	4	123	9	125	2	44	134	5	136	0	137	6	139	1
45	**126**	**7**	**128**	**0**	**129**	**5**	**130**	**10**	**45**	**140**	**7**	**142**	**2**	**143**	**9**	**145**	**4**
46	132	3	133	8	135	2	136	7	46	146	11	148	6	150	2	151	9
47	138	1	139	6	141	0	142	6	47	153	5	155	0	156	8	158	4
48	144	0	145	6	147	0	148	6	48	160	0	161	8	163	4	165	0
49	150	1	151	7	153	2	154	8	49	166	9	168	5	170	2	171	10
50	**156**	**3**	**157**	**10**	**159**	**5**	**161**	**0**	**50**	**173**	**7**	**175**	**4**	**177**	**1**	**178**	**10**

Quarter Girt.	11 feet long.								Quarter Girt.	12 feet long.							
			1/4		1/2		3/4					1/4		1/2		3/4	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		4		5		6		7	2		4		5		6		7
3		8		10		11	1	1	3		9		10	1	0	1	2
4	1	3	1	4	1	6	1	9	4	1	4	1	6	1	8	1	10
5	**1**	**11**	**2**	**1**	**2**	**4**	**2**	**6**	**5**	**2**	**1**	**2**	**3**	**2**	**6**	**2**	**9**
6	2	9	3	0	3	3	3	6	6	3	0	3	3	3	6	3	9
7	3	9	4	0	4	3	4	7	7	4	1	4	4	4	8	5	0
8	4	11	5	2	5	6	5	10	8	5	4	5	8	6	0	6	4
9	6	2	6	6	6	11	7	3	9	6	9	7	1	7	6	7	11
10	**7**	**8**	**8**	**0**	**8**	**5**	**8**	**10**	**10**	**8**	**4**	**8**	**9**	**9**	**2**	**9**	**7**
11	9	3	9	8	10	1	10	6	11	10	1	10	6	11	0	11	6
12	11	0	11	5	11	11	12	5	12	12	0	12	6	13	0	13	6
13	12	11	13	5	13	11	14	5	13	14	1	14	7	15	2	15	9
14	15	0	15	6	16	1	16	7	14	16	4	16	11	17	6	18	1
15	**17**	**2**	**17**	**9**	**18**	**4**	**18**	**11**	**15**	**18**	**9**	**19**	**4**	**20**	**0**	**20**	**8**
16	19	7	20	2	20	9	21	5	16	21	4	22	0	22	8	23	4
17	22	1	22	9	23	5	24	1	17	24	1	24	9	25	6	26	3
18	24	9	25	5	26	2	26	10	18	27	0	27	9	28	6	29	3
19	27	7	28	4	29	0	29	9	19	30	1	30	10	31	8	32	6
20	**30**	**7**	**31**	**4**	**32**	**1**	**32**	**11**	**20**	**33**	**4**	**34**	**2**	**35**	**0**	**35**	**10**
21	33	8	34	6	35	4	36	2	21	36	9	37	7	38	6	39	5
22	37	0	37	10	38	8	39	6	22	40	4	41	3	42	2	43	1
23	40	5	41	3	42	2	43	11	23	44	1	45	0	46	0	47	0
24	44	0	44	11	45	10	46	9	24	48	0	49	0	50	0	51	0
25	**47**	**9**	**48**	**8**	**49**	**8**	**50**	**8**	**25**	**52**	**1**	**53**	**1**	**54**	**2**	**55**	**3**
26	51	8	52	8	53	8	54	8	26	56	4	57	5	58	6	59	7
27	55	8	56	9	57	9	58	10	27	60	9	61	10	63	0	64	2
28	59	11	60	11	62	0	63	2	28	65	4	66	6	67	8	68	10
29	64	3	65	4	66	6	67	7	29	70	1	71	3	72	6	73	9
30	**68**	**9**	**69**	**11**	**71**	**1**	**72**	**3**	**30**	**75**	**0**	**76**	**3**	**77**	**6**	**78**	**9**
31	73	5	74	7	75	9	77	0	31	80	1	81	4	82	8	84	0
32	78	3	79	5	80	8	81	11	32	85	4	86	8	88	0	89	4
33	83	2	84	5	85	9	87	0	33	90	9	92	1	93	6	94	11
34	88	4	89	7	90	11	92	3	34	96	4	97	9	99	2	100	7
35	**93**	**7**	**94**	**11**	**96**	**3**	**97**	**7**	**35**	**102**	**1**	**103**	**6**	**105**	**0**	**106**	**6**
36	99	0	100	4	101	9	103	2	36	108	0	109	6	111	0	112	5
37	104	7	106	0	107	5	108	10	37	114	1	115	7	117	2	118	9
38	110	4	111	9	113	3	114	8	38	120	4	121	11	123	6	125	1
39	116	2	117	8	119	2	120	8	39	126	9	128	4	130	0	131	8
40	**122**	**3**	**123**	**9**	**125**	**3**	**126**	**10**	**40**	**133**	**4**	**135**	**0**	**136**	**8**	**138**	**4**
41	128	5	130	0	131	7	133	2	41	140	1	141	9	143	6	145	3
42	134	9	136	3	138	0	139	7	42	147	0	148	8	150	6	152	5
43	141	3	142	11	144	6	146	2	43	154	1	155	10	157	8	159	6
44	147	11	149	7	151	3	153	0	44	161	4	163	2	165	0	166	10
45	**154**	**8**	**156**	**5**	**158**	**2**	**159**	**11**	**45**	**168**	**9**	**170**	**7**	**172**	**6**	**174**	**5**
46	161	8	163	5	165	2	166	11	46	176	4	178	3	180	2	182	1
47	168	9	170	6	172	4	174	2	47	184	1	186	0	188	0	190	0
48	176	0	177	10	179	8	181	6	48	192	0	194	0	196	0	198	0
49	183	5	185	3	187	2	189	1	49	200	1	202	1	204	2	206	3
50	**191**	**0**	**192**	**11**	**194**	**10**	**196**	**9**	**50**	**208**	**4**	**210**	**5**	**212**	**6**	**214**	**7**

Quarter Girt.	13 feet long.								Quarter Girt.	14 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		4		5		7		8	2		5		6		7		9
3		10		11	1	1	1	3	3		10	1	0	1	2	1	4
4	1	5	1	7	1	10	2	0	4	1	7	1	9	2	0	2	2
5	**2**	**3**	**2**	**6**	**2**	**9**	**3**	**0**	**5**	**2**	**5**	**2**	**8**	**2**	**11**	**3**	**2**
6	3	3	3	6	3	10	4	1	6	3	6	3	9	4	1	4	5
7	4	5	4	9	5	1	5	5	7	4	9	5	1	5	5	5	10
8	5	9	6	2	6	6	6	11	8	6	3	6	7	7	0	7	5
9	7	4	7	9	8	2	8	7	9	7	10	8	4	8	9	9	3
10	**9**	**0**	**9**	**6**	**9**	**11**	**10**	**5**	**10**	**9**	**9**	**10**	**2**	**10**	**9**	**11**	**3**
11	10	11	11	5	11	11	12	5	11	11	9	12	4	12	10	13	5
12	13	0	13	6	14	1	14	8	12	14	0	14	7	15	2	15	10
13	15	3	15	10	16	5	17	1	13	16	5	17	1	17	9	18	4
14	17	8	18	4	19	0	19	8	14	19	1	19	9	20	5	21	2
15	**20**	**4**	**21**	**0**	**21**	**8**	**22**	**5**	**15**	**21**	**10**	**22**	**7**	**23**	**4**	**24**	**1**
16	23	1	23	10	24	7	25	4	16	24	11	25	8	26	6	27	3
17	26	1	26	10	27	8	28	5	17	28	1	28	11	29	9	30	7
18	29	3	30	1	30	11	31	9	18	31	6	32	4	33	3	34	2
19	32	7	33	5	34	3	35	2	19	35	1	36	0	37	0	37	11
20	**36**	**1**	**37**	**0**	**37**	**11**	**38**	**10**	**20**	**38**	**11**	**39**	**10**	**40**	**10**	**41**	**10**
21	39	10	40	9	41	9	42	8	21	42	10	43	11	44	11	46	0
22	43	8	44	8	45	8	46	9	22	47	1	48	1	49	3	50	3
23	47	9	48	10	49	10	50	11	23	51	5	52	7	53	8	54	10
24	52	0	53	1	54	2	55	4	24	56	0	57	2	58	4	59	7
25	**56**	**5**	**57**	**7**	**58**	**8**	**59**	**10**	**25**	**60**	**9**	**62**	**0**	**63**	**3**	**64**	**5**
26	61	0	62	2	63	5	64	7	26	65	9	67	0	68	3	69	7
27	65	10	67	0	68	3	69	6	27	70	10	72	2	73	6	74	10
28	70	9	72	0	73	4	74	7	28	76	3	77	7	79	0	80	4
29	75	11	77	3	78	7	79	11	29	81	9	83	2	84	7	86	0
30	**81**	**3**	**82**	**7**	**84**	**0**	**85**	**4**	**30**	**87**	**6**	**88**	**11**	**90**	**5**	**91**	**11**
31	86	9	88	2	89	7	91	0	31	93	5	94	11	96	5	98	0
32	92	5	93	11	95	4	96	10	32	99	7	101	1	102	8	104	3
33	98	4	99	9	101	4	102	10	33	105	10	107	6	109	1	110	9
34	104	4	105	11	107	5	109	0	34	112	5	114	0	115	9	117	5
35	**110**	**7**	**112**	**2**	**113**	**9**	**115**	**4**	**35**	**119**	**1**	**120**	**10**	**122**	**6**	**124**	**3**
36	117	0	118	7	120	3	121	11	36	126	0	127	9	129	6	131	4
37	123	7	125	3	126	11	128	8	37	133	1	134	10	136	8	138	6
38	130	4	132	1	133	10	135	7	38	140	5	142	3	144	1	145	11
39	137	4	139	1	140	10	142	8	39	147	10	149	9	151	8	153	7
40	**144**	**5**	**146**	**3**	**148**	**1**	**149**	**11**	**40**	**155**	**7**	**157**	**6**	**159**	**6**	**161**	**5**
41	151	9	153	7	155	6	157	4	41	163	5	165	2	167	5	169	5
42	159	3	161	1	163	1	165	0	42	171	6	173	5	175	7	177	8
43	166	11	168	10	170	10	172	9	43	179	9	181	10	183	11	186	1
44	174	9	176	9	178	9	180	9	44	188	3	190	4	192	6	194	8
45	**182**	**10**	**184**	**10**	**186**	**11**	**188**	**11**	**45**	**196**	**10**	**199**	**1**	**201**	**3**	**203**	**6**
46	191	0	193	1	195	2	197	4	46	205	9	207	11	210	3	212	6
47	199	5	201	7	203	8	205	10	47	214	9	217	1	219	4	221	8
48	208	0	210	2	212	4	214	7	48	224	0	226	4	228	8	231	0
49	216	9	218	11	221	2	223	5	49	233	5	235	10	238	3	240	7
50	**225**	**8**	**227**	**11**	**230**	**3**	**232**	**6**	**50**	**243**	**1**	**245**	**6**	**247**	**11**	**250**	**5**

Quarter Girt.	15 feet long.								Quarter Girt.	16 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		5		6		8		9	2		5		7		8		10
3		11	1	1	1	3	1	5	3	1	0	1	2	1	4	1	7
4	1	8	1	10	2	1	2	4	4	1	9	2	0	2	3	2	6
5	**2**	**7**	**2**	**10**	**3**	**2**	**3**	**5**	**5**	**2**	**9**	**3**	**1**	**3**	**4**	**3**	**8**
6	3	9	4	1	4	5	4	9	6	4	0	4	4	4	8	5	1
7	5	1	5	6	5	10	6	3	7	5	5	5	10	6	3	6	8
8	6	8	7	1	7	6	8	0	8	7	1	7	7	8	0	8	6
9	8	5	8	11	9	5	9	11	9	9	0	9	6	10	0	10	7
10	**10**	**5**	**10**	**11**	**11**	**6**	**12**	**0**	**10**	**11**	**1**	**11**	**8**	**12**	**3**	**12**	**10**
11	12	7	13	2	13	9	14	4	11	13	5	14	1	14	8	15	4
12	15	0	15	7	16	3	16	11	12	16	0	16	8	17	4	18	1
13	17	7	18	3	19	0	19	8	13	18	9	19	6	20	3	21	0
14	20	5	21	2	21	11	22	8	14	21	9	22	7	23	4	24	2
15	**23**	**5**	**24**	**3**	**25**	**0**	**25**	**10**	**15**	**25**	**0**	**25**	**10**	**26**	**8**	**27**	**7**
16	26	8	27	6	28	4	29	3	16	28	5	29	4	30	3	31	2
17	30	1	31	0	31	11	32	10	17	32	1	33	1	34	0	35	0
18	33	9	34	8	35	8	36	7	18	36	0	37	0	38	0	39	1
19	37	7	38	7	39	7	40	7	19	40	1	41	2	42	3	43	4
20	**41**	**8**	**42**	**8**	**43**	**9**	**44**	**10**	**20**	**44**	**5**	**45**	**7**	**46**	**8**	**47**	**10**
21	45	11	47	0	48	2	49	3	21	49	0	50	2	51	4	52	7
22	50	5	51	7	52	9	53	11	22	53	9	55	0	56	3	57	6
23	55	1	56	4	57	6	58	9	23	58	9	60	1	61	4	62	8
24	60	0	61	3	62	6	63	10	24	64	0	65	4	66	8	68	1
25	**65**	**1**	**66**	**5**	**67**	**9**	**69**	**0**	**25**	**69**	**5**	**70**	**9**	**72**	**3**	**73**	**8**
26	70	5	71	9	73	2	74	6	26	75	1	76	7	78	0	79	6
27	75	11	77	4	78	9	80	2	27	81	0	82	6	84	0	85	7
28	81	8	83	1	84	7	86	1	28	87	1	88	8	90	3	91	10
29	87	7	89	1	90	8	92	2	29	93	5	95	1	96	8	98	4
30	**93**	**9**	**95**	**4**	**96**	**11**	**98**	**6**	**30**	**100**	**0**	**101**	**8**	**103**	**4**	**105**	**1**
31	100	1	101	9	103	4	105	0	31	106	9	108	6	110	3	112	0
32	106	8	108	4	110	0	111	9	32	113	9	115	7	117	4	119	2
33	113	5	115	2	116	11	118	8	33	121	0	122	10	124	8	126	7
34	120	5	122	2	124	0	125	9	34	128	5	130	4	132	3	134	2
35	**127**	**7**	**129**	**5**	**131**	**3**	**133**	**1**	**35**	**136**	**1**	**138**	**1**	**140**	**0**	**142**	**0**
36	135	0	136	10	138	9	140	8	36	144	0	146	0	148	0	150	1
37	142	7	144	6	146	6	148	5	37	152	1	154	2	156	3	158	4
38	150	5	152	5	154	5	156	5	38	160	5	162	6	164	8	166	10
39	158	5	160	5	162	6	164	7	39	169	0	171	2	173	4	175	7
40	**166**	**8**	**168**	**9**	**170**	**10**	**173**	**0**	**40**	**177**	**9**	**180**	**0**	**182**	**3**	**184**	**6**
41	175	1	177	3	179	5	181	7	41	186	9	189	1	191	4	193	8
42	183	9	185	10	188	2	190	4	42	196	0	198	3	200	8	203	1
43	192	7	194	10	197	1	199	4	43	205	5	207	10	210	3	212	8
44	201	8	203	11	206	3	208	7	44	215	1	217	7	220	0	222	6
45	**210**	**11**	**213**	**3**	**215**	**7**	**218**	**0**	**45**	**225**	**0**	**227**	**6**	**230**	**0**	**232**	**7**
46	220	5	222	10	225	2	227	8	46	235	1	237	8	240	3	242	10
47	230	1	232	7	235	0	237	6	47	245	5	248	1	250	8	253	4
48	240	0	242	6	245	0	247	6	48	256	0	258	8	261	4	264	0
49	250	0	252	8	255	2	257	10	49	266	9	269	6	272	3	275	0
50	**260**	**5**	**263**	**0**	**265**	**8**	**268**	**3**	**50**	**277**	**9**	**280**	**7**	**283**	**4**	**286**	**2**

Quarter Girt.	17 feet long.								Quarter Girt.	18 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		6		7		9		11	2		6		8		9		11
3	1	1	1	3	1	5	1	8	3	1	1	1	4	1	6	1	9
4	1	11	2	2	2	5	2	8	4	2	0	2	3	2	6	2	10
5	**2**	**11**	**3**	**3**	**3**	**7**	**3**	**11**	**5**	**3**	**1**	**3**	**5**	**3**	**9**	**4**	**2**
6	4	3	4	7	5	0	5	4	6	4	6	4	11	5	3	5	8
7	5	9	6	2	6	8	7	1	7	6	1	6	7	7	0	7	6
8	7	7	8	0	8	6	9	0	8	8	0	8	6	9	0	9	7
9	9	7	10	1	10	8	11	3	9	10	1	10	8	11	3	11	11
10	**11**	**10**	**12**	**5**	**13**	**0**	**13**	**8**	**10**	**12**	**6**	**13**	**2**	**13**	**9**	**14**	**5**
11	14	3	14	11	15	7	16	4	11	15	1	15	10	16	6	17	3
12	17	0	17	9	18	5	19	2	12	18	0	18	9	19	6	20	4
13	19	11	20	9	21	6	22	4	13	21	1	21	11	22	9	23	8
14	23	2	24	0	24	10	25	8	14	24	6	25	5	26	3	27	2
15	**26**	**7**	**27**	**5**	**28**	**4**	**29**	**3**	**15**	**28**	**1**	**29**	**1**	**30**	**0**	**31**	**0**
16	30	3	31	2	32	2	33	1	16	32	0	33	0	34	0	35	1
17	34	1	35	1	36	2	37	2	17	36	1	37	2	38	3	39	5
18	38	3	39	4	40	5	41	6	18	40	6	41	8	42	9	43	11
19	42	7	43	9	44	11	46	1	19	45	1	46	4	47	6	48	9
20	**47**	**3**	**48**	**5**	**49**	**7**	**50**	**10**	**20**	**50**	**0**	**51**	**3**	**52**	**6**	**53**	**10**
21	52	1	53	4	54	7	55	10	21	55	1	56	5	57	9	59	2
22	57	2	58	5	59	9	61	1	22	60	6	61	11	63	3	64	8
23	62	5	63	10	65	2	66	7	23	66	1	67	7	69	0	70	6
24	68	0	69	5	70	10	72	4	24	72	0	73	6	75	0	76	7
25	**73**	**9**	**75**	**3**	**76**	**9**	**78**	**3**	**25**	**78**	**1**	**79**	**8**	**81**	**3**	**82**	**11**
26	79	10	81	4	82	11	84	6	26	84	6	86	2	87	9	89	5
27	86	1	87	8	89	3	90	11	27	91	1	92	10	94	6	96	3
28	92	7	94	3	95	11	97	7	28	98	0	99	9	101	6	103	4
29	99	3	101	0	102	9	104	6	29	105	1	106	11	108	9	110	8
30	**106**	**3**	**108**	**0**	**109**	**10**	**111**	**7**	**30**	**112**	**6**	**114**	**5**	**116**	**3**	**118**	**2**
31	113	5	115	3	117	2	119	0	31	120	1	122	1	124	0	126	0
32	120	11	122	9	124	8	126	7	32	128	0	130	0	132	0	134	1
33	128	7	130	6	132	6	134	6	33	136	1	138	2	140	3	142	5
34	136	6	138	6	140	6	142	7	34	144	6	146	8	148	9	150	11
35	**144**	**7**	**146**	**8**	**148**	**9**	**150**	**11**	**35**	**153**	**1**	**155**	**4**	**157**	**6**	**159**	**9**
36	153	0	155	2	157	3	159	5	36	162	0	164	3	166	6	168	10
37	161	7	163	10	166	0	168	0	37	171	1	173	5	175	9	178	2
38	170	6	172	9	175	0	177	3	38	180	6	182	11	185	3	187	8
39	179	7	181	10	184	2	186	6	39	190	1	192	7	195	0	197	6
40	**188**	**11**	**191**	**3**	**193**	**8**	**196**	**0**	**40**	**200**	**0**	**202**	**6**	**205**	**0**	**207**	**7**
41	198	5	200	10	203	4	205	9	41	210	1	212	8	215	3	217	11
42	208	3	210	7	213	3	215	9	42	220	6	223	0	225	9	228	5
43	218	3	220	10	223	5	226	0	43	231	1	233	10	236	6	239	3
44	228	7	231	2	233	9	236	5	44	242	0	244	9	247	6	250	4
45	**239**	**1**	**241**	**9**	**244**	**5**	**247**	**1**	**45**	**253**	**1**	**255**	**11**	**258**	**9**	**261**	**8**
46	249	10	252	6	253	3	258	0	46	264	6	267	5	270	3	273	2
47	260	9	263	7	266	4	269	2	47	276	1	279	1	282	0	285	0
48	272	0	274	10	277	8	280	7	48	288	0	291	0	294	0	297	1
49	283	5	286	4	289	3	292	2	49	300	1	303	2	306	3	309	5
50	**295**	**2**	**298**	**1**	**301**	**1**	**304**	**7**	**50**	**312**	**6**	**315**	**8**	**318**	**9**	**321**	**11**

Quarter Girt.	19 feet long.								Quarter Girt.	20 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		6		8		10	1	0	2		7		8		10	1	1
3	1	2	1	5	1	7	1	10	3	1	3	1	6	1	8	1	11
4	2	1	2	5	2	8	3	0	4	2	3	2	6	2	10	3	2
5	**3**	**4**	**3**	**8**	**4**	**0**	**4**	**4**	**5**	**3**	**6**	**3**	**10**	**4**	**2**	**4**	**7**
6	4	9	5	2	5	7	6	0	6	5	0	5	5	5	10	6	4
7	6	6	6	11	7	5	7	11	7	6	10	7	4	7	10	8	4
8	8	5	9	0	9	6	10	1	8	8	11	9	5	10	0	10	8
9	10	8	11	3	11	11	12	6	9	11	3	11	11	12	6	13	2
10	**13**	**2**	**13**	**10**	**14**	**6**	**15**	**3**	**10**	**13**	**11**	**14**	**7**	**15**	**4**	**16**	**1**
11	16	0	16	8	17	5	18	3	11	16	10	17	7	18	4	19	2
12	19	0	19	10	20	7	21	5	12	20	0	20	10	21	8	22	7
13	22	4	23	2	24	0	24	11	13	23	6	24	5	25	4	26	3
14	25	10	26	9	27	9	28	8	14	27	3	28	2	29	2	30	3
15	**29**	**8**	**30**	**8**	**31**	**8**	**32**	**9**	**15**	**31**	**3**	**32**	**4**	**33**	**4**	**34**	**5**
16	33	9	34	10	35	11	37	0	16	35	7	36	8	37	9	39	0
17	38	2	39	3	40	5	41	7	17	40	2	41	4	42	6	43	9
18	42	9	43	11	45	2	46	5	18	45	0	46	3	47	6	48	10
19	47	8	48	11	50	2	51	6	19	50	2	51	6	52	10	54	2
20	**52**	**9**	**54**	**1**	**55**	**5**	**56**	**10**	**20**	**55**	**7**	**56**	**11**	**58**	**4**	**59**	**10**
21	58	2	59	7	61	0	62	5	21	61	3	62	9	64	2	65	8
22	63	10	65	4	66	9	68	3	22	67	3	68	9	70	4	71	11
23	69	9	71	4	72	10	74	5	23	73	6	75	1	76	8	78	4
24	76	0	77	7	79	2	80	10	24	80	0	81	8	83	4	85	1
25	**82**	**6**	**84**	**1**	**85**	**9**	**87**	**6**	**25**	**86**	**10**	**88**	**7**	**90**	**4**	**92**	**1**
26	89	2	90	11	92	8	94	5	26	93	11	95	8	97	6	99	5
27	96	2	98	0	99	9	101	7	27	101	3	103	2	105	0	106	11
28	103	5	105	4	107	2	109	1	28	108	11	110	10	112	10	114	10
29	111	0	112	11	114	10	116	9	29	116	10	118	10	120	10	122	11
30	**118**	**9**	**120**	**9**	**122**	**9**	**124**	**9**	**30**	**125**	**0**	**127**	**1**	**129**	**2**	**131**	**4**
31	126	10	128	10	130	11	133	0	31	133	6	135	8	137	10	140	0
32	135	1	137	3	139	4	141	6	32	142	3	144	5	146	8	149	0
33	143	8	145	10	148	1	150	3	33	151	3	153	7	155	10	158	2
34	152	6	154	9	157	0	159	4	34	160	7	162	11	165	4	167	9
35	**161**	**8**	**163**	**11**	**166**	**3**	**168**	**8**	**35**	**170**	**2**	**172**	**7**	**175**	**0**	**177**	**6**
36	171	0	173	5	175	9	178	2	36	180	0	182	6	185	0	187	7
37	180	8	183	1	185	6	188	0	37	190	2	192	9	195	4	197	11
38	190	6	193	0	195	7	198	1	38	200	7	203	2	205	10	208	7
39	200	8	203	3	205	10	208	6	39	211	3	214	0	216	8	219	5
40	**211**	**1**	**213**	**9**	**216**	**5**	**219**	**1**	**40**	**222**	**3**	**225**	**0**	**227**	**10**	**230**	**8**
41	221	10	224	6	227	3	230	0	41	233	6	236	4	239	2	242	1
42	232	9	235	5	238	4	241	2	42	245	0	247	9	250	10	253	10
43	244	0	246	10	249	8	252	7	43	256	10	259	10	262	10	265	10
44	255	5	258	4	261	3	264	3	44	268	11	271	11	275	0	278	2
45	**267**	**2**	**270**	**2**	**273**	**2**	**276**	**2**	**45**	**281**	**3**	**284**	**5**	**287**	**6**	**290**	**8**
46	279	2	282	3	285	3	288	4	46	293	11	297	1	300	4	303	7
47	291	6	294	7	297	8	300	10	47	306	10	310	1	313	4	316	8
48	304	0	307	2	310	4	313	7	48	320	0	323	4	326	8	330	1
49	316	10	320	0	323	3	326	7	49	333	6	336	11	340	4	343	9
50	**329**	**10**	**333**	**2**	**336**	**6**	**339**	**10**	**50**	**347**	**3**	**350**	**8**	**354**	**2**	**357**	**9**

Quarter Girt.	21 feet long.								Quarter Girt.	22 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		7		9		11	1	1	2		7		9		11	1	2
3	1	4	1	6	1	9	2	1	3	1	4	1	7	1	10	2	2
4	2	4	2	8	2	11	3	3	4	2	5	2	9	3	1	3	5
5	**3**	**8**	**4**	**0**	**4**	**5**	**4**	**10**	**5**	**3**	**10**	**4**	**2**	**4**	**7**	**5**	**1**
6	5	3	5	8	6	2	6	8	6	5	6	6	0	6	5	6	11
7	7	2	7	8	8	2	8	9	7	7	6	8	0	8	7	9	2
8	9	4	9	11	10	6	11	2	8	9	9	10	5	11	0	11	8
9	11	10	12	6	13	2	13	10	9	12	4	13	1	13	9	14	6
10	**14**	**7**	**15**	**4**	**16**	**1**	**16**	**10**	**10**	**15**	**3**	**16**	**1**	**16**	**10**	**17**	**8**
11	17	8	18	5	19	3	20	2	11	18	6	19	4	20	2	21	1
12	21	0	22	11	22	9	23	8	12	22	0	22	11	23	10	24	10
13	24	8	25	7	26	7	27	7	13	25	10	26	10	27	10	28	11
14	28	7	29	7	30	8	31	9	14	29	11	31	0	32	1	33	3
15	**32**	**10**	**33**	**11**	**35**	**0**	**36**	**2**	**15**	**34**	**4**	**35**	**6**	**36**	**8**	**37**	**11**
16	37	4	38	6	39	8	40	11	16	39	1	40	4	41	7	42	10
17	42	2	43	5	44	8	45	11	17	44	2	45	5	46	9	48	2
18	47	3	48	7	49	11	51	3	18	49	6	50	11	52	3	53	8
19	52	8	54	0	55	5	56	11	19	55	2	56	7	58	1	59	7
20	**58**	**4**	**59**	**10**	**61**	**3**	**62**	**9**	**20**	**61**	**1**	**62**	**8**	**64**	**2**	**65**	**9**
21	64	4	65	10	67	5	69	0	21	67	4	69	0	70	7	72	3
22	70	7	72	2	73	10	75	6	22	73	11	75	8	77	4	79	1
23	77	2	78	10	80	6	82	3	23	80	10	82	7	84	4	86	2
24	84	0	85	9	87	6	89	4	24	88	0	89	10	91	8	93	7
25	**91**	**2**	**93**	**0**	**94**	**10**	**96**	**8**	**25**	**95**	**6**	**97**	**5**	**99**	**4**	**101**	**4**
26	98	7	100	6	102	5	104	4	26	103	3	105	3	107	3	109	4
27	106	4	108	3	110	3	112	4	27	111	4	113	5	115	6	117	8
28	114	4	116	5	118	5	120	6	28	119	9	121	11	124	1	126	3
29	122	8	124	9	126	11	129	1	29	128	6	130	8	132	11	135	3
30	**131**	**3**	**133**	**5**	**135**	**8**	**137**	**11**	**30**	**137**	**6**	**139**	**10**	**142**	**1**	**144**	**5**
31	140	2	142	5	144	8	147	0	31	146	10	149	2	151	7	154	0
32	149	4	151	8	154	0	156	5	32	156	5	158	11	161	4	163	10
33	158	9	161	3	163	8	166	1	33	166	4	168	11	171	5	174	0
34	168	7	171	1	173	7	176	1	34	176	7	179	3	181	10	184	6
35	**178**	**8**	**181**	**2**	**183**	**9**	**186**	**5**	**35**	**187**	**2**	**189**	**10**	**192**	**6**	**195**	**3**
36	189	0	191	8	194	3	196	11	36	198	0	200	9	203	6	206	4
37	199	8	202	4	205	1	207	10	37	209	2	212	0	214	10	217	9
38	210	7	213	4	216	2	219	0	38	220	7	223	6	226	5	229	5
39	221	10	224	8	227	6	230	5	39	232	4	235	4	238	4	241	5
40	**233**	**4**	**236**	**3**	**239**	**2**	**242**	**2**	**40**	**244**	**5**	**247**	**6**	**250**	**7**	**253**	**8**
41	245	2	248	2	251	2	254	2	41	256	10	259	11	263	1	266	4
42	257	3	260	2	263	5	266	6	42	269	6	272	7	275	11	279	2
43	269	8	272	9	275	11	279	2	43	282	6	285	9	289	1	292	5
44	282	4	285	7	288	9	292	0	44	295	9	299	2	302	6	305	11
45	**295**	**4**	**298**	**7**	**301**	**11**	**305**	**3**	**45**	**309**	**4**	**312**	**10**	**316**	**3**	**319**	**9**
46	308	7	311	11	315	4	318	9	46	323	3	326	10	330	4	333	11
47	322	2	325	7	329	0	332	6	47	337	6	341	1	344	8	348	4
48	336	0	339	6	343	0	346	7	48	352	0	355	8	359	4	363	1
49	350	2	353	9	357	4	360	11	49	366	10	370	7	374	4	378	2
50	**364**	**7**	**368**	**3**	**371**	**11**	**375**	**7**	**50**	**381**	**11**	**385**	**9**	**389**	**7**	**393**	**6**

Quarter Girt.	23 feet long.								Quarter Girt.	24 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		8		10	1	0	1	2	2		8		10	1	0	1	3
3	1	5	1	8	1	11	2	3	3	1	6	1	9	2	0	2	4
4	2	7	2	11	3	3	3	7	4	2	8	3	0	3	4	3	9
5	**4**	**0**	**4**	**5**	**4**	**10**	**5**	**3**	**5**	**4**	**2**	**4**	**7**	**5**	**0**	**5**	**6**
6	5	9	6	3	6	9	7	3	6	6	0	6	6	7	0	7	7
7	7	10	8	5	9	0	9	7	7	8	2	8	9	9	4	10	0
8	10	3	10	10	11	6	12	3	8	10	8	11	4	12	0	12	9
9	12	11	13	8	14	5	15	2	9	13	6	14	3	15	0	15	10
10	**16**	**0**	**16**	**9**	**17**	**7**	**18**	**5**	**10**	**16**	**8**	**17**	**6**	**18**	**4**	**19**	**3**
11	19	4	20	2	21	1	22	1	11	20	2	21	1	22	0	23	0
12	23	0	24	0	24	11	25	11	12	24	0	25	0	26	0	27	1
13	27	0	28	0	29	1	30	2	13	28	2	29	3	30	4	31	6
14	31	4	32	5	33	7	34	9	14	32	8	33	10	35	0	36	3
15	**35**	**11**	**37**	**2**	**38**	**4**	**39**	**7**	**15**	**37**	**6**	**38**	**9**	**40**	**0**	**41**	**4**
16	40	11	42	2	43	6	44	10	16	42	8	44	0	45	4	46	9
17	46	2	47	6	48	11	50	4	17	48	2	49	7	51	0	52	6
18	51	9	53	2	54	8	56	2	18	54	0	55	6	57	0	58	7
19	57	8	59	2	60	9	62	4	19	60	2	61	9	63	4	65	0
20	**63**	**11**	**65**	**6**	**67**	**1**	**68**	**9**	**20**	**66**	**8**	**68**	**4**	**70**	**0**	**71**	**9**
21	70	5	72	1	73	10	75	7	21	73	6	75	3	77	0	78	10
22	77	4	79	1	80	10	82	8	22	80	8	82	6	84	4	86	3
23	84	6	86	4	88	2	90	1	23	88	2	90	1	92	0	94	0
24	92	0	93	11	95	10	97	10	24	96	0	98	0	100	0	102	1
25	**99**	**10**	**101**	**10**	**103**	**10**	**105**	**11**	**25**	**104**	**2**	**106**	**3**	**108**	**4**	**110**	**6**
26	108	0	110	1	112	2	114	3	26	112	8	114	10	117	0	119	3
27	116	5	118	7	120	9	123	0	27	121	6	123	9	126	0	128	4
28	125	3	127	6	129	9	132	0	28	130	8	133	0	135	4	137	9
29	134	4	136	8	139	0	141	4	29	140	2	142	7	145	0	147	6
30	**143**	**9**	**146**	**2**	**148**	**7**	**151**	**0**	**30**	**150**	**0**	**152**	**6**	**155**	**0**	**157**	**7**
31	153	6	156	0	158	6	161	0	31	160	2	162	9	165	4	168	0
32	163	7	166	1	168	8	171	4	32	170	8	173	4	176	0	178	9
33	173	11	176	7	179	3	181	11	33	181	6	184	3	187	0	189	10
34	184	8	187	4	191	1	192	10	34	192	8	195	6	198	4	201	3
35	**195**	**8**	**198**	**5**	**201**	**3**	**204**	**1**	**35**	**204**	**2**	**207**	**1**	**210**	**0**	**213**	**0**
36	207	0	209	11	212	9	215	8	36	216	0	219	0	222	0	225	1
37	218	8	221	7	224	7	227	7	37	228	2	231	3	234	4	237	6
38	230	8	233	8	236	9	239	10	38	240	8	243	10	247	0	250	3
39	242	11	246	0	249	2	252	4	39	253	6	256	9	260	0	263	4
40	**255**	**7**	**258**	**9**	**262**	**0**	**265**	**3**	**40**	**266**	**8**	**270**	**0**	**273**	**4**	**276**	**9**
41	268	6	271	9	275	1	278	5	41	280	2	283	7	287	0	290	6
42	281	9	284	11	288	6	291	11	42	294	0	297	4	301	0	304	7
43	295	4	298	9	302	3	305	9	43	308	2	311	9	315	4	319	0
44	309	3	312	9	316	3	319	10	44	322	8	326	4	330	0	333	9
45	**323**	**5**	**327**	**0**	**330**	**8**	**334**	**4**	**45**	**337**	**6**	**341**	**3**	**345**	**0**	**348**	**10**
46	338	0	341	8	345	4	349	1	46	352	8	356	6	360	4	364	3
47	352	10	356	7	360	4	364	2	47	368	2	372	1	376	0	380	0
48	368	0	371	10	375	8	379	7	48	384	0	388	0	392	0	396	1
49	383	6	387	5	391	4	395	4	49	400	2	404	3	408	4	412	6
50	**399**	**4**	**403**	**4**	**407**	**4**	**411**	**4**	**50**	**416**	**8**	**420**	**10**	**425**	**0**	**429**	**3**

Quarter Girt.	25 feet long.								Quarter Girt.	26 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		8		10	1	1	1	4	2		9		11	1	1	1	4
3	1	7	1	10	2	1	2	5	3	1	7	1	11	2	2	2	6
4	2	9	3	2	3	6	3	11	4	2	11	3	3	3	8	4	1
5	**4**	**4**	**4**	**9**	**5**	**3**	**5**	**9**	**5**	**4**	**6**	**5**	**0**	**5**	**5**	**6**	**0**
6	6	3	6	9	7	4	7	11	6	6	6	7	1	7	7	8	3
7	8	6	9	1	9	9	10	5	7	8	10	9	6	10	2	10	10
8	11	1	11	10	12	6	13	3	8	11	7	12	3	13	0	13	10
9	14	1	14	10	15	8	16	6	9	14	7	15	5	16	3	17	2
10	**17**	**4**	**18**	**3**	**19**	**1**	**20**	**1**	**10**	**18**	**1**	**19**	**0**	**19**	**11**	**20**	**10**
11	21	0	22	0	22	11	24	0	11	21	10	22	10	23	10	24	11
12	25	0	26	1	27	1	28	3	12	26	0	27	1	28	2	29	4
13	29	4	30	6	31	8	32	10	13	30	6	31	8	32	10	34	2
14	34	0	35	3	36	6	37	10	14	35	5	36	8	37	11	39	3
15	**39**	**1**	**40**	**4**	**41**	**8**	**43**	**1**	**15**	**40**	**7**	**42**	**0**	**43**	**4**	**44**	**9**
16	44	5	45	10	47	3	48	8	16	46	3	47	8	49	2	50	8
17	50	2	51	8	53	2	54	8	17	52	2	53	9	55	3	56	11
18	56	3	57	10	59	5	61	0	18	58	6	60	2	61	9	63	6
19	62	8	64	4	66	0	67	9	19	65	2	66	11	68	8	70	5
20	**69**	**5**	**71**	**2**	**72**	**11**	**74**	**9**	**20**	**72**	**3**	**74**	**0**	**75**	**10**	**77**	**9**
21	76	7	78	5	80	3	82	1	21	79	8	81	6	83	5	85	5
22	84	0	85	11	87	11	89	10	22	87	5	89	5	91	5	93	5
23	91	10	93	10	95	10	97	11	23	95	6	97	7	99	8	101	10
24	100	0	102	1	104	2	106	4	24	104	0	106	2	108	4	110	7
25	**108**	**6**	**110**	**8**	**112**	**11**	**115**	**1**	**25**	**112**	**10**	**115**	**1**	**117**	**5**	**119**	**9**
26	117	4	119	7	121	11	124	3	26	122	1	124	5	126	9	129	2
27	126	7	128	11	131	3	133	8	27	131	7	134	1	136	6	139	0
28	136	1	138	7	141	0	143	6	28	141	7	144	1	146	8	149	3
29	146	0	148	6	151	1	153	8	29	151	10	154	10	157	1	159	10
30	**156**	**3**	**158**	**10**	**161**	**6**	**164**	**2**	**30**	**162**	**6**	**165**	**3**	**167**	**11**	**170**	**9**
31	166	10	169	6	172	3	175	0	31	173	6	176	4	179	2	182	0
32	177	9	180	7	183	4	186	2	32	184	11	187	9	190	8	193	8
33	189	0	191	11	194	10	197	9	33	196	7	199	7	202	7	205	8
34	200	8	203	8	206	8	209	8	34	208	9	211	10	214	11	218	0
35	**212**	**8**	**215**	**8**	**218**	**9**	**221**	**11**	**35**	**221**	**2**	**224**	**4**	**227**	**6**	**230**	**9**
36	225	0	228	2	231	3	234	6	36	234	0	237	3	240	6	243	10
37	237	8	240	11	244	2	247	5	37	247	2	250	6	253	11	257	4
38	250	8	254	0	257	4	260	8	38	260	9	264	2	267	7	271	1
39	264	0	267	5	270	10	274	4	39	274	7	278	2	281	8	285	3
40	**277**	**9**	**281**	**3**	**284**	**9**	**289**	**3**	**40**	**288**	**11**	**292**	**6**	**296**	**2**	**299**	**10**
41	291	10	295	5	299	0	302	7	41	303	6	307	3	310	11	314	9
42	306	3	309	9	313	7	317	3	42	318	6	322	1	326	1	330	0
43	321	0	324	9	328	6	332	4	43	333	10	337	9	341	8	345	7
44	336	1	339	11	343	9	347	8	44	349	7	353	6	357	6	361	7
45	**351**	**7**	**355**	**6**	**359**	**5**	**363**	**4**	**45**	**365**	**7**	**369**	**8**	**373**	**9**	**377**	**11**
46	367	4	371	4	375	5	379	5	46	382	1	386	3	390	5	394	7
47	383	6	387	7	391	8	395	10	47	398	10	403	1	407	4	411	8
48	400	0	404	2	408	4	412	7	48	416	0	420	4	424	8	429	1
49	416	10	421	1	425	5	429	8	49	433	6	437	11	442	5	446	11
50	**434**	**0**	**438**	**4**	**442**	**9**	**447**	**2**	**50**	**451**	**5**	**455**	**11**	**460**	**5**	**465**	**0**

Quarter Girt.	27 feet long.								Quarter Girt.	28 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		9		11	1	2	1	5	2		9	1	0	1	3	1	6
3	1	8	2	0	2	3	2	8	3	1	9	2	1	2	5	2	9
4	3	0	3	5	3	9	4	3	4	3	1	3	6	3	11	4	5
5	**4**	**8**	**5**	**2**	**5**	**8**	**6**	**2**	**5**	**4**	**10**	**5**	**4**	**5**	**10**	**6**	**5**
6	6	9	7	4	8	0	8	6	6	7	0	7	7	8	3	8	10
7	9	2	9	10	10	6	11	3	7	9	6	10	3	10	11	11	8
8	12	0	12	9	13	6	14	4	8	12	5	13	3	14	1	14	11
9	15	2	16	0	16	11	17	10	9	15	9	16	8	17	7	18	6
10	**18**	**9**	**19**	**8**	**20**	**8**	**21**	**8**	**10**	**19**	**5**	**20**	**5**	**21**	**5**	**22**	**6**
11	22	8	23	9	24	9	25	11	11	23	6	24	7	25	9	26	10
12	27	0	28	2	29	3	30	6	12	28	0	29	2	30	5	31	7
13	31	8	32	11	34	2	35	2	13	32	10	34	2	35	5	36	9
14	36	9	38	1	39	5	40	9	14	38	1	39	6	40	11	42	4
15	**42**	**2**	**43**	**7**	**45**	**0**	**46**	**6**	**15**	**43**	**9**	**45**	**3**	**46**	**9**	**48**	**3**
16	48	0	49	6	51	0	52	7	16	49	9	51	4	52	11	54	7
17	54	2	55	9	57	5	59	1	17	56	2	57	10	59	7	61	3
18	60	9	62	5	64	2	65	11	18	63	0	64	9	66	7	68	4
19	67	8	69	6	71	3	73	2	19	70	2	72	1	73	11	75	10
20	**75**	**0**	**76**	**11**	**78**	**9**	**80**	**9**	**20**	**77**	**9**	**79**	**9**	**81**	**9**	**83**	**9**
21	82	8	84	8	86	8	88	8	21	85	9	87	10	89	11	91	11
22	90	9	92	10	94	11	97	0	22	94	1	96	3	98	5	100	8
23	99	2	101	4	103	6	105	9	23	102	10	105	1	107	5	109	8
24	108	0	110	3	112	6	114	10	24	112	0	114	4	116	9	119	1
25	**117**	**2**	**119**	**6**	**121**	**11**	**124**	**4**	**25**	**121**	**6**	**124**	**0**	**126**	**5**	**128**	**11**
26	126	9	129	2	131	8	134	2	26	131	5	134	0	136	7	139	2
27	136	8	139	3	141	9	144	5	27	141	9	144	5	147	1	149	9
28	147	0	149	8	152	3	154	11	28	152	5	155	2	157	11	160	9
29	157	8	160	5	163	2	165	11	29	163	6	166	4	169	3	172	1
30	**168**	**9**	**171**	**7**	**174**	**5**	**177**	**3**	**30**	**175**	**0**	**177**	**11**	**180**	**11**	**183**	**10**
31	180	2	183	1	186	0	189	0	31	186	10	189	11	192	11	196	0
32	192	0	195	0	198	0	201	1	32	199	1	202	2	205	5	208	7
33	204	2	207	3	210	5	213	7	33	211	9	215	0	218	3	221	6
34	216	9	219	11	223	2	226	5	34	224	9	228	1	231	5	234	10
35	**229**	**8**	**232**	**11**	**236**	**3**	**239**	**8**	**35**	**238**	**2**	**241**	**7**	**245**	**1**	**248**	**6**
36	243	0	246	5	249	9	253	3	36	252	0	255	6	259	1	262	7
37	256	8	260	2	263	8	267	2	37	266	2	269	10	273	5	277	1
38	270	9	274	4	277	11	281	6	38	280	9	284	6	288	3	292	0
39	285	2	288	10	292	6	296	3	39	295	9	299	7	303	5	307	3
40	**300**	**0**	**303**	**9**	**307**	**6**	**311**	**4**	**40**	**311**	**1**	**315**	**0**	**318**	**11**	**322**	**11**
41	315	2	319	0	322	11	326	10	41	326	10	330	10	334	11	338	11
42	330	9	334	6	338	8	342	8	42	343	0	346	11	351	3	355	4
43	346	8	350	8	354	9	358	1	43	359	6	363	9	367	11	372	11
44	363	0	367	2	371	3	375	6	44	376	5	380	9	385	1	389	5
45	**379**	**8**	**383**	**11**	**388**	**2**	**392**	**5**	**45**	**393**	**9**	**398**	**2**	**402**	**7**	**407**	**0**
46	396	5	401	1	405	5	409	9	46	411	5	415	11	420	5	425	0
47	414	2	418	7	423	0	427	6	47	429	6	434	1	438	9	443	4
48	432	0	436	6	441	0	445	7	48	448	0	452	8	457	5	462	1
49	450	2	454	9	459	5	464	1	49	466	10	471	8	476	5	481	3
50	**468**	**9**	**473**	**5**	**478**	**2**	**482**	**11**	**50**	**486**	**1**	**491**	**0**	**495**	**11**	**500**	**10**

Quarter Girt.	29 feet long.								Quarter Girt.	30 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		10	1	0	1	3	1	6	2		10	1	1	1	4	1	7
3	1	10	2	1	2	6	2	10	3	1	10	2	2	2	7	2	11
4	3	3	3	8	4	1	4	6	4	3	4	3	9	4	3	4	8
5	**5**	**0**	**5**	**7**	**6**	**1**	**6**	**8**	**5**	**5**	**2**	**5**	**9**	**6**	**4**	**6**	**11**
6	7	3	7	10	8	6	9	2	6	7	6	8	2	8	10	9	6
7	9	10	10	7	11	4	12	1	7	10	3	10	11	11	9	12	6
8	12	11	13	8	14	7	15	5	8	13	4	14	2	15	1	15	11
9	16	4	17	3	18	2	19	2	9	16	10	17	10	18	10	19	10
10	**20**	**2**	**21**	**2**	**22**	**2**	**23**	**3**	**10**	**20**	**10**	**21**	**11**	**23**	**0**	**24**	**1**
11	24	4	25	6	26	8	27	10	11	25	2	26	4	27	7	28	9
12	29	0	30	3	31	6	32	8	12	30	0	31	3	32	7	33	10
13	34	0	35	4	36	8	38	1	13	35	2	36	7	38	0	39	5
14	39	6	40	11	42	4	43	10	14	40	10	42	4	43	10	45	4
15	**45**	**4**	**46**	**10**	**48**	**5**	**49**	**11**	**15**	**46**	**10**	**48**	**5**	**50**	**1**	**51**	**8**
16	51	7	53	2	54	10	56	6	16	53	4	55	0	56	9	58	5
17	58	2	59	11	61	8	63	5	17	60	2	62	0	63	10	65	8
18	65	3	67	1	68	11	70	10	18	67	6	69	5	71	4	73	3
19	72	8	74	7	76	7	78	7	19	75	2	77	2	79	3	81	3
20	**80**	**7**	**82**	**7**	**84**	**8**	**86**	**8**	**20**	**83**	**4**	**85**	**5**	**87**	**7**	**89**	**8**
21	88	10	90	11	93	1	95	3	21	91	10	94	10	96	4	98	7
22	97	6	99	8	101	11	104	3	22	100	10	103	2	105	6	107	10
23	106	6	108	10	111	3	113	7	23	110	2	112	7	115	1	117	6
24	116	0	118	5	120	11	123	4	24	120	0	122	6	125	1	127	7
25	**125**	**10**	**128**	**5**	**130**	**11**	**133**	**6**	**25**	**130**	**2**	**132**	**10**	**135**	**6**	**138**	**2**
26	136	2	138	9	141	5	144	1	26	140	10	143	7	146	4	149	1
27	146	10	149	7	152	4	155	1	27	151	10	154	8	157	7	160	5
28	157	11	160	9	163	7	166	5	28	163	4	166	3	169	3	172	2
29	169	4	172	4	175	3	178	3	29	175	2	178	3	181	4	184	5
30	**181**	**3**	**184**	**3**	**187**	**4**	**190**	**5**	**30**	**187**	**6**	**190**	**8**	**193**	**10**	**197**	**0**
31	193	6	196	8	199	10	203	0	31	200	2	203	5	206	9	210	0
32	206	3	209	5	212	9	216	0	32	213	4	216	8	220	1	223	5
33	219	4	222	8	226	0	229	5	33	226	10	230	4	233	10	237	4
34	232	10	236	3	239	8	243	2	34	240	10	244	5	248	0	251	7
35	**246**	**8**	**250**	**3**	**253**	**1**	**257**	**5**	**35**	**255**	**2**	**258**	**10**	**262**	**7**	**266**	**3**
36	261	0	264	8	268	4	272	0	36	270	0	273	9	277	7	281	4
37	275	8	279	5	283	2	287	0	37	285	2	289	1	293	0	296	11
38	290	10	294	8	298	6	302	5	38	300	10	304	10	308	10	312	10
39	306	4	310	3	314	3	318	2	39	316	10	320	11	325	1	329	2
40	**322**	**3**	**326**	**3**	**330**	**4**	**334**	**5**	**40**	**333**	**4**	**337**	**6**	**341**	**9**	**345**	**11**
41	338	6	342	8	346	10	351	0	41	350	2	354	6	358	10	363	2
42	355	3	359	3	363	9	368	1	42	367	6	371	8	376	4	380	9
43	372	4	376	8	381	1	385	6	43	385	2	389	8	394	3	398	9
44	389	11	394	4	398	10	403	3	44	403	4	407	11	412	7	417	2
45	**407**	**10**	**412**	**4**	**416**	**11**	**421**	**6**	**45**	**421**	**10**	**426**	**7**	**431**	**4**	**436**	**1**
46	426	2	430	9	435	5	440	2	46	440	10	445	8	450	6	455	4
47	444	10	449	7	454	5	459	2	47	460	2	465	1	470	1	475	0
48	464	0	468	10	473	8	478	7	48	480	0	485	0	490	1	495	1
49	483	6	488	6	493	5	498	5	49	500	2	505	4	510	6	515	8
50	**503**	**6**	**508**	**6**	**513**	**7**	**518**	**8**	**50**	**520**	**10**	**526**	**1**	**531**	**4**	**536**	**7**

Quarter Girt.	31 feet long.								Quarter Girt.	32 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		10	1	1	1	4	1	7	2		11	1	2	1	5	1	8
3	1	11	2	3	2	8	3	0	3	2	0	2	4	2	9	3	2
4	3	5	3	11	4	4	4	10	4	3	7	4	0	4	6	5	0
5	**5**	**5**	**5**	**11**	**6**	**6**	**7**	**1**	**5**	**5**	**7**	**6**	**2**	**6**	**9**	**7**	**4**
6	7	9	8	5	9	1	9	10	6	8	0	8	8	9	5	10	2
7	10	7	11	4	12	1	12	11	7	11	11	11	8	12	6	13	4
8	13	9	14	8	15	7	10	6	8	14	3	15	2	16	1	17	0
9	17	5	18	5	19	5	20	6	9	18	0	19	0	20	1	21	2
10	**21**	**6**	**22**	**7**	**23**	**9**	**24**	**11**	**10**	**22**	**3**	**23**	**4**	**24**	**6**	**25**	**8**
11	26	1	25	3	28	6	29	9	11	26	11	28	2	29	5	30	8
12	31	0	32	4	33	8	35	0	12	32	0	33	4	34	9	36	2
13	36	5	37	10	39	3	40	8	13	37	7	39	0	40	6	42	0
14	42	2	43	9	45	3	46	10	14	43	5	45	2	46	9	48	4
15	**48**	**5**	**50**	**1**	**51**	**9**	**53**	**5**	**15**	**50**	**0**	**51**	**8**	**55**	**5**	**55**	**2**
16	55	1	56	10	58	7	60	5	16	56	11	58	8	60	6	62	4
17	62	3	64	1	65	11	67	10	17	64	3	66	2	68	1	70	0
18	69	9	71	8	73	8	75	8	18	72	0	74	0	76	1	78	2
19	77	9	79	9	81	10	84	0	19	80	3	82	4	84	6	86	9
20	**86**	**1**	**88**	**3**	**90**	**6**	**92**	**8**	**20**	**88**	**11**	**91**	**2**	**93**	**5**	**95**	**8**
21	94	11	97	2	99	6	101	10	21	98	0	100	4	102	9	105	2
22	104	2	106	7	109	0	111	5	22	107	7	110	0	112	6	115	0
23	113	11	116	4	118	11	121	5	23	117	7	120	2	129	9	125	4
24	124	0	126	7	129	3	131	10	24	128	0	130	8	133	5	136	2
25	**134**	**7**	**137**	**3**	**140**	**0**	**142**	**9**	**25**	**138**	**11**	**141**	**9**	**144**	**6**	**147**	**4**
26	145	6	148	4	151	2	154	0	26	150	3	153	1	156	1	158	11
27	156	11	159	10	162	10	165	9	27	162	0	165	0	168	1	171	2
28	168	9	171	10	174	10	177	11	28	174	3	177	4	180	6	183	8
29	181	1	184	2	187	4	190	6	29	186	11	192	2	193	5	196	8
30	**193**	**9**	**197**	**0**	**200**	**3**	**203**	**7**	**30**	**200**	**0**	**203**	**4**	**206**	**9**	**210**	**2**
31	206	11	210	3	213	7	217	0	31	213	7	217	0	220	6	224	0
32	220	5	223	11	227	5	230	11	32	227	7	231	2	234	9	238	4
33	234	5	238	0	241	7	245	3	33	242	0	245	8	249	5	253	2
34	249	10	252	6	256	3	260	0	34	256	11	260	8	264	6	268	4
35	**263**	**9**	**267**	**6**	**271**	**4**	**275**	**2**	**35**	**272**	**3**	**276**	**2**	**280**	**1**	**284**	**0**
36	279	0	282	11	289	10	290	9	36	288	0	292	0	296	1	300	2
37	294	9	298	9	302	9	306	9	37	304	3	308	4	312	6	316	8
38	310	10	315	0	319	1	323	3	38	320	11	325	2	329	5	333	8
39	327	5	331	8	335	11	340	2	39	338	0	342	4	346	9	351	2
40	**344**	**5**	**348**	**9**	**353**	**1**	**357**	**6**	**40**	**355**	**7**	**360**	**0**	**364**	**6**	**369**	**0**
41	361	11	366	4	370	9	375	3	41	373	7	378	2	382	9	387	4
42	379	9	384	1	388	10	393	5	42	392	0	396	6	401	5	406	2
43	398	1	402	8	407	4	412	1	43	410	11	415	8	420	6	425	4
44	416	9	421	6	426	4	431	1	44	430	3	435	2	440	1	445	0
45	**435**	**11**	**440**	**9**	**445**	**8**	**450**	**7**	**45**	**450**	**0**	**455**	**0**	**460**	**1**	**465**	**2**
46	455	6	460	6	465	6	470	6	46	470	3	475	4	480	6	485	8
47	475	7	480	7	485	9	490	10	47	490	11	496	2	501	5	506	8
48	496	0	501	2	506	5	511	7	48	512	0	517	4	522	9	528	1
49	516	11	522	2	527	6	532	10	49	533	7	539	0	544	0	550	0
50	**538**	**2**	**543**	**7**	**549**	**0**	**554**	**6**	**50**	**555**	**7**	**561**	**2**	**566**	**9**	**572**	**4**

Quarter Girt.	33 feet long.								Quarter Girt.	34 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2		11	1	2	1	5	1	9	2		11	1	2	1	6	1	9
3	2	1	2	5	2	10	3	3	3	2	2	2	6	2	11	3	4
4	3	8	4	2	4	8	5	2	4	3	9	4	3	4	9	5	4
5	**5**	**9**	**6**	**4**	**6**	**11**	**7**	**7**	**5**	**5**	**11**	**6**	**6**	**7**	**2**	**7**	**10**
6	8	3	8	11	9	8	10	5	6	8	6	9	3	10	0	10	9
7	11	3	12	1	12	11	13	9	7	11	7	12	5	13	3	14	2
8	14	8	15	7	16	7	17	7	8	15	1	16	1	17	1	18	1
9	18	7	19	7	20	8	21	9	9	19	2	20	2	21	4	22	5
10	**22**	**11**	**24**	**1**	**25**	**3**	**26**	**6**	**10**	**23**	**7**	**24**	**10**	**26**	**0**	**27**	**3**
11	27	9	29	0	30	4	31	8	11	28	7	29	11	31	3	32	7
12	33	0	34	5	35	10	37	4	12	34	0	35	5	36	11	38	5
13	38	9	40	3	41	9	43	4	13	39	11	41	5	43	0	44	8
14	44	11	46	6	48	2	49	10	14	46	3	47	11	49	8	51	4
15	**51**	**7**	**53**	**4**	**55**	**1**	**56**	**10**	**15**	**53**	**2**	**54**	**11**	**56**	**9**	**58**	**7**
16	58	8	60	6	62	5	64	4	16	60	5	62	4	64	3	66	3
17	66	3	68	2	70	2	72	2	17	68	3	70	3	72	4	74	5
18	74	3	76	4	78	5	80	7	18	76	6	78	8	80	10	83	0
19	82	9	84	11	87	2	89	4	19	85	3	87	6	89	9	92	2
20	**91**	**8**	**94**	**0**	**96**	**4**	**98**	**8**	**20**	**94**	**5**	**96**	**10**	**99**	**3**	**101**	**8**
21	101	1	103	6	105	11	108	5	21	104	2	106	7	109	2	111	8
22	110	11	113	5	116	0	118	7	22	114	3	116	11	119	6	122	2
23	121	3	123	11	126	7	129	3	23	124	11	127	8	130	5	133	2
24	132	0	134	9	137	7	140	5	24	136	0	138	10	141	9	144	8
25	**143**	**3**	**146**	**1**	**149**	**0**	**151**	**11**	**25**	**147**	**7**	**150**	**6**	**153**	**6**	**156**	**7**
26	154	11	157	11	160	11	163	11	26	159	7	162	8	165	10	168	10
27	167	1	170	2	173	4	176	6	27	172	2	175	4	178	7	181	10
28	179	8	182	11	186	2	189	5	28	185	1	188	5	191	9	195	2
29	192	9	196	1	199	5	202	10	29	198	7	202	0	205	6	209	0
30	**206**	**3**	**209**	**8**	**213**	**2**	**216**	**8**	**30**	**212**	**6**	**216**	**1**	**219**	**8**	**223**	**3**
31	220	3	223	10	227	5	231	0	31	226	11	230	7	234	3	238	0
32	234	8	238	4	242	1	245	10	32	241	9	245	7	249	5	253	3
33	249	7	253	4	257	2	261	0	33	257	2	261	0	265	0	268	11
34	264	11	268	10	272	9	276	9	34	272	11	277	0	281	0	285	1
35	**280**	**9**	**284**	**9**	**288**	**10**	**292**	**11**	**35**	**289**	**3**	**293**	**5**	**297**	**7**	**301**	**9**
36	297	0	301	2	305	4	309	6	36	306	0	310	3	314	7	318	11
37	313	9	318	0	322	3	326	7	37	323	3	327	7	332	0	336	6
38	330	11	335	3	339	8	344	1	38	340	11	345	5	350	0	354	6
39	348	7	353	1	357	7	362	1	39	359	2	363	9	368	5	373	1
40	**366**	**8**	**371**	**3**	**375**	**11**	**380**	**7**	**40**	**377**	**9**	**382**	**6**	**387**	**3**	**392**	**1**
41	385	3	389	11	394	8	399	5	41	396	11	401	9	406	8	411	7
42	404	3	408	10	413	11	418	10	42	416	6	421	3	426	6	431	6
43	423	9	428	8	433	8	438	8	43	436	7	441	8	446	9	451	11
44	443	8	448	9	453	10	458	11	44	457	1	462	4	467	7	472	10
45	**464**	**1**	**469**	**3**	**474**	**5**	**479**	**8**	**45**	**478**	**2**	**483**	**5**	**488**	**10**	**494**	**2**
46	484	11	490	2	495	6	500	10	46	499	7	505	1	510	6	516	0
47	506	3	511	8	517	1	522	6	47	521	7	527	2	532	9	538	4
48	528	0	533	6	539	1	544	8	48	544	0	549	8	555	5	561	2
49	550	3	555	10	561	6	567	2	49	566	11	572	8	578	6	584	5
50	**572**	**11**	**578**	**8**	**584**	**5**	**590**	**3**	**50**	**590**	**3**	**596**	**2**	**602**	**2**	**608**	**1**

Quarter Girt.	35 feet long.								Quarter Girt.	36 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2	1	0	1	3	1	6	1	10	2	1	0	1	3	1	7	1	11
3	2	2	2	7	3	0	3	5	3	2	3	2	8	3	1	3	6
4	3	11	4	5	4	11	5	6	4	4	0	4	6	5	1	5	8
5	**6**	**1**	**6**	**8**	**7**	**4**	**8**	**0**	**5**	**6**	**3**	**6**	**11**	**7**	**7**	**8**	**3**
6	8	9	9	6	10	3	11	1	6	9	0	9	9	10	7	11	5
7	11	11	12	9	13	8	14	7	7	12	3	13	2	14	1	15	0
8	15	7	16	7	17	7	18	7	8	16	0	17	0	18	1	19	2
9	19	8	20	10	21	11	23	1	9	20	3	21	5	22	7	23	9
10	**24**	**4**	**25**	**6**	**26**	**10**	**28**	**1**	**10**	**25**	**0**	**26**	**3**	**27**	**7**	**28**	**11**
11	29	5	30	9	32	2	33	7	11	30	3	31	8	33	1	34	6
12	35	0	36	6	38	0	39	6	12	36	0	37	6	39	1	40	8
13	41	1	42	8	44	4	45	11	13	42	3	43	11	45	7	47	3
14	47	8	49	4	51	1	52	11	14	49	0	50	9	52	7	54	5
15	**54**	**8**	**56**	**6**	**58**	**5**	**60**	**4**	**15**	**56**	**3**	**58**	**2**	**60**	**1**	**62**	**0**
16	61	3	64	2	66	2	68	2	16	64	0	66	0	68	1	70	2
17	70	3	72	4	74	5	76	1	17	72	3	74	5	76	7	78	9
18	78	9	80	11	83	2	85	5	18	81	0	83	3	85	7	87	11
19	87	9	90	0	92	5	94	10	19	90	3	92	8	95	1	97	6
20	**97**	**3**	**99**	**8**	**102**	**2**	**104**	**8**	**20**	**100**	**0**	**102**	**6**	**105**	**1**	**107**	**8**
21	107	2	109	9	112	4	115	0	21	110	3	112	11	115	7	118	3
22	117	8	120	4	123	1	125	10	22	121	0	123	9	126	7	129	5
23	128	7	131	5	134	3	137	1	23	132	3	135	2	138	1	141	0
24	140	0	142	11	145	11	148	11	24	144	0	147	0	150	1	153	2
25	**151**	**11**	**155**	**0**	**158**	**1**	**161**	**2**	**25**	**156**	**3**	**159**	**5**	**162**	**7**	**165**	**9**
26	164	4	167	6	170	8	173	10	26	169	0	172	3	175	7	178	11
27	177	2	180	5	183	10	187	2	27	182	3	185	8	189	1	192	6
28	190	7	194	0	197	5	200	11	28	196	0	199	6	203	1	206	8
29	204	5	207	11	211	6	215	1	29	210	3	213	11	217	7	221	3
30	**218**	**9**	**222**	**5**	**226**	**1**	**229**	**10**	**30**	**225**	**0**	**228**	**9**	**232**	**7**	**236**	**5**
31	233	7	237	4	241	2	245	0	31	240	3	244	2	248	1	252	0
32	248	11	252	10	256	9	260	8	32	256	0	260	0	264	1	268	2
33	264	9	268	9	272	9	276	10	33	272	3	276	5	280	7	284	9
34	281	0	285	1	289	4	293	6	34	289	0	293	3	297	7	301	11
35	**297**	**9**	**302**	**0**	**306**	**4**	**310**	**8**	**35**	**306**	**3**	**310**	**8**	**315**	**1**	**319**	**6**
36	315	0	319	5	323	10	328	3	36	324	0	328	6	333	1	337	8
37	332	9	337	3	341	10	346	4	37	342	3	346	11	351	7	356	3
38	351	0	355	7	360	3	365	0	38	361	0	365	9	370	7	375	5
39	369	8	374	5	379	3	384	1	39	380	3	385	2	390	1	395	0
40	**388**	**11**	**393**	**9**	**398**	**8**	**403**	**7**	**40**	**400**	**0**	**405**	**0**	**410**	**1**	**415**	**2**
41	408	7	413	7	418	7	423	8	41	420	3	425	5	430	7	435	9
42	428	9	433	8	439	0	444	2	42	441	0	446	0	451	7	456	11
43	449	5	454	8	459	11	465	2	43	462	3	467	8	473	1	478	6
44	470	7	475	11	481	4	486	9	44	484	0	489	6	495	1	500	8
45	**492**	**2**	**497**	**8**	**503**	**2**	**508**	**9**	**45**	**506**	**3**	**511**	**11**	**517**	**7**	**523**	**3**
46	514	4	519	11	525	7	531	3	46	529	0	534	9	540	7	546	5
47	536	11	542	8	548	5	554	2	47	552	3	558	1	564	1	570	0
48	560	0	565	10	571	0	577	8	48	576	0	582	0	588	1	594	2
49	583	7	589	7	595	7	601	7	49	600	3	606	5	612	7	618	9
50	**607**	**8**	**613**	**9**	**619**	**10**	**626**	**0**	**50**	**625**	**0**	**631**	**3**	**637**	**7**	**643**	**11**

Quarter Girt.	37 feet long.								Quarter Girt.	38 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2	1	0	1	4	1	7	1	11	2	1	1	1	4	1	8	1	11
3	2	4	2	9	3	2	3	7	3	2	5	2	9	3	3	3	9
4	4	1	4	8	5	2	5	10	4	4	3	4	9	5	4	5	11
5	**6**	**5**	**7**	**1**	**7**	**9**	**8**	**6**	**5**	**6**	**7**	**7**	**3**	**8**	**0**	**8**	**9**
6	9	3	10	0	10	10	11	8	6	9	6	10	4	11	2	12	0
7	12	7	13	6	14	5	15	5	7	12	11	13	10	14	10	15	10
8	16	5	17	6	18	7	19	8	8	16	11	18	0	19	1	20	2
9	20	10	22	0	23	2	24	5	9	21	5	22	7	23	10	25	1
10	**25**	**8**	**27**	**0**	**28**	**4**	**29**	**8**	**10**	**26**	**5**	**27**	**9**	**29**	**1**	**30**	**6**
11	31	1	32	6	34	0	35	6	11	31	11	33	5	34	11	36	5
12	37	0	38	7	40	2	41	9	12	38	0	39	7	41	3	42	11
13	43	5	45	1	47	0	48	7	13	44	7	46	4	48	1	49	11
14	50	4	52	2	54	0	55	11	14	51	9	53	7	55	6	57	5
15	**57**	**10**	**59**	**9**	**61**	**9**	**63**	**9**	**15**	**59**	**5**	**61**	**4**	**63**	**5**	**65**	**6**
16	65	9	67	10	69	11	72	1	16	67	7	69	8	71	10	74	0
17	74	3	76	5	78	8	80	11	17	76	3	78	6	80	10	83	2
18	83	3	85	7	87	11	90	4	18	85	6	87	11	90	3	92	9
19	92	9	95	3	97	8	100	2	19	95	3	97	9	100	4	102	11
20	**102**	**9**	**105**	**4**	**108**	**0**	**110**	**8**	**20**	**105**	**7**	**108**	**3**	**110**	**11**	**113**	**7**
21	113	4	116	0	118	9	121	7	21	116	5	119	2	122	0	124	10
22	124	4	127	2	130	1	133	0	22	127	9	130	8	133	7	136	7
23	135	11	138	11	141	11	144	11	23	139	7	142	8	145	9	148	10
24	148	0	151	1	154	3	157	5	24	152	0	155	2	158	5	161	8
25	**160**	**7**	**163**	**10**	**167**	**1**	**170**	**4**	**25**	**164**	**11**	**168**	**3**	**171**	**7**	**175**	**0**
26	173	8	177	1	180	5	183	10	26	178	5	181	10	185	4	188	10
27	187	4	190	10	194	4	197	10	27	192	5	195	11	199	7	203	3
28	201	5	205	0	208	8	212	5	28	206	11	210	7	214	4	218	1
29	216	1	219	10	223	0	227	5	29	221	11	225	9	229	8	233	7
30	**231**	**3**	**235**	**1**	**239**	**0**	**242**	**11**	**30**	**237**	**6**	**241**	**6**	**245**	**6**	**249**	**6**
31	246	11	250	11	254	11	259	0	31	253	7	257	8	261	10	266	0
32	263	1	267	3	271	5	275	7	32	270	3	274	6	278	9	283	0
33	279	10	284	1	288	4	292	8	33	287	5	291	9	296	2	300	7
34	297	0	301	5	305	10	310	3	34	305	1	309	7	314	1	318	8
35	**314**	**9**	**319**	**3**	**323**	**10**	**328**	**5**	**35**	**323**	**3**	**327**	**11**	**332**	**7**	**337**	**3**
36	333	0	337	8	342	4	347	0	36	342	0	346	9	351	7	356	5
37	351	9	356	6	361	4	366	2	37	361	3	366	2	371	1	376	1
38	371	0	375	11	380	10	385	10	38	381	1	386	1	391	2	396	3
39	390	10	395	10	400	11	405	12	39	401	5	406	6	411	9	417	0
40	**411**	**1**	**416**	**3**	**421**	**5**	**426**	**8**	**40**	**422**	**3**	**427**	**6**	**432**	**10**	**438**	**2**
41	431	11	437	2	442	6	445	10	41	443	7	449	0	454	6	460	0
42	453	3	458	5	464	1	469	7	42	465	6	470	10	476	8	482	3
43	475	1	480	8	486	2	491	10	43	487	11	493	7	499	4	501	1
44	497	5	503	1	508	10	514	7	44	510	11	516	9	522	7	528	5
45	**520**	**4**	**526**	**1**	**531**	**11**	**537**	**10**	**45**	**534**	**5**	**540**	**4**	**546**	**4**	**552**	**4**
46	543	8	549	7	555	7	561	7	46	558	5	564	6	570	7	576	9
47	567	7	573	8	579	9	585	10	47	582	11	589	2	595	5	601	8
48	592	0	598	2	604	5	610	8	48	608	0	614	4	620	9	627	2
49	616	11	623	3	629	7	635	11	49	633	7	640	1	646	7	653	2
50	**642**	**4**	**648**	**10**	**655**	**3**	**661**	**9**	**50**	**659**	**9**	**666**	**4**	**673**	**0**	**679**	**8**

Quarter Girt.	39 feet long.								Quarter Girt.	40 feet long.							
			¼		½		¾					¼		½		¾	
inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.	inches	ft.	in.	ft.	in.	ft.	in.	ft.	in.
2	1	1	1	4	1	8	2	1	2	1	1	1	5	1	9	2	1
3	2	5	2	10	3	4	3	10	3	2	6	2	11	3	5	3	11
4	4	4	4	11	5	6	6	1	4	4	5	5	0	5	7	6	3
5	**6**	**9**	**7**	**6**	**8**	**2**	**8**	**11**	**5**	**6**	**11**	**7**	**8**	**8**	**5**	**9**	**2**
6	9	9	10	7	11	5	12	4	6	10	0	10	10	11	9	12	8
7	13	3	14	3	15	3	16	3	7	13	7	14	7	15	7	16	8
8	17	4	18	5	19	7	20	9	8	17	9	18	11	20	1	21	3
9	21	11	23	2	24	5	25	9	9	22	6	23	9	25	1	26	5
10	**27**	**1**	**28**	**5**	**29**	**10**	**31**	**4**	**10**	**27**	**9**	**29**	**2**	**30**	**7**	**32**	**1**
11	32	9	34	3	35	10	37	5	11	33	7	35	2	36	9	38	4
12	39	0	40	8	42	4	44	0	12	40	0	41	8	43	5	45	2
13	45	9	47	7	49	4	51	2	13	46	11	48	9	50	7	52	6
14	53	1	55	0	57	0	58	11	14	54	5	56	5	58	5	60	5
15	**60**	**11**	**63**	**0**	**65**	**1**	**67**	**2**	**15**	**62**	**6**	**64**	**7**	**66**	**9**	**68**	**11**
16	69	4	71	6	73	9	76	0	16	71	1	73	4	75	7	77	11
17	78	3	80	7	82	11	85	4	17	80	3	82	8	85	1	87	6
18	87	9	90	2	92	8	95	3	18	90	0	92	6	95	1	97	8
19	97	9	100	4	103	0	105	8	19	100	3	102	11	105	7	108	4
20	**108**	**4**	**111**	**1**	**113**	**10**	**116**	**7**	**20**	**111**	**1**	**113**	**11**	**116**	**9**	**119**	**7**
21	119	5	122	4	125	2	128	1	21	122	6	125	5	128	5	131	5
22	131	1	134	1	137	1	140	2	22	134	5	137	6	140	7	143	9
23	143	3	146	5	149	7	152	9	23	146	11	150	2	153	5	156	8
24	156	0	159	3	162	7	165	11	24	160	0	163	4	166	9	170	2
25	**169**	**3**	**172**	**8**	**176**	**1**	**179**	**7**	**25**	**173**	**7**	**177**	**1**	**180**	**7**	**184**	**2**
26	183	1	186	7	190	2	193	10	26	187	9	191	5	195	1	198	9
27	197	5	201	1	204	10	208	7	27	202	6	206	3	210	1	213	11
28	212	4	216	2	220	0	223	10	28	217	9	221	8	225	7	229	7
29	227	9	231	9	235	8	239	8	29	233	7	237	8	241	9	245	10
30	**243**	**9**	**247**	**10**	**251**	**11**	**256**	**1**	**30**	**250**	**0**	**254**	**2**	**258**	**5**	**262**	**8**
31	260	3	264	6	268	9	273	0	31	266	11	271	3	275	7	280	0
32	277	4	281	8	286	1	290	6	32	284	5	288	11	293	5	297	11
33	294	11	299	5	303	11	308	6	33	302	6	307	1	311	9	316	5
34	313	1	317	8	322	4	327	0	34	321	1	325	10	330	7	335	5
35	**331**	**9**	**336**	**6**	**341**	**4**	**346**	**2**	**35**	**340**	**3**	**345**	**2**	**350**	**1**	**355**	**0**
36	351	0	355	11	360	10	365	9	36	360	0	365	0	370	1	375	2
37	370	9	375	10	380	10	385	11	37	380	3	385	5	390	7	395	10
38	391	1	396	3	401	5	406	8	38	401	1	406	5	411	9	417	1
39	411	11	417	3	422	7	427	11	39	422	6	427	11	433	5	438	11
40	**433**	**4**	**438**	**9**	**444**	**3**	**449**	**9**	**40**	**444**	**5**	**450**	**0**	**455**	**7**	**461**	**3**
41	455	3	460	10	466	5	472	1	41	466	11	472	8	478	5	484	2
42	477	9	483	2	489	2	495	0	42	490	0	495	7	501	9	507	8
43	500	9	506	7	512	6	518	5	43	513	7	519	7	525	7	531	8
44	524	4	530	4	536	4	542	4	44	537	9	543	11	550	1	556	3
45	**548**	**5**	**554**	**6**	**560**	**8**	**566**	**10**	**45**	**562**	**6**	**568**	**9**	**575**	**1**	**581**	**5**
46	573	1	579	4	585	7	591	11	46	587	9	594	2	600	7	607	1
47	598	3	604	8	611	1	617	6	47	613	7	620	2	626	9	633	4
48	624	0	630	6	637	1	643	8	48	640	0	646	8	653	5	660	2
49	650	3	656	11	663	7	670	4	49	666	11	673	9	680	7	687	6
50	**677**	**1**	**683**	**10**	**690**	**8**	**697**	**6**	**50**	**694**	**5**	**701**	**5**	**708**	**5**	**715**	**5**

TIMBER TABLES, No. II.

Tables of unequal sided Timber, and side of equal square.

Each page of these Tables contains twelve columns. In the outer column on either side is set down the greater side in inches, and in the remaining columns are contained the side of equal square corresponding to the unequal sides.

Use of the Table.

Ex. 1.—A piece of timber 27½ inches broad, and 40½ inches deep, what is the side of equal square?

In the column headed 27½ inches lesser side, and opposite 40½ inches greater side, stands 33¼ inches side of equal square.

Ex. 2.—A piece of timber 25 feet long, 23½ inches broad, and 37½ inches thick, what is its solid content?

In Table, No. 2, under 23½ inches lesser side, and opposite 37½ inches greater side, is 29¾ inches side of equal square.

In Table, No 1, in the portion headed 25 feet long, opposite 29 inches quarter girt, and in the column headed ¾ inches, is 153 ft. 8 in. solid content.

It is not unfrequent in practice for measurers to add together the unequal sides and consider half their sum as the side of equal square. When there is not much difference in the dimensions of the two sides, this is not productive of great error; but the two preceding examples will show, that when the sides are very disproportioned the error is considerable.

In *Ex.* 1,

27½	
40½	
2) 68	sum of two sides
34	mean
33¼	True side of equal square.
¾	difference.

In *Ex.* 2,

$23\frac{1}{2}$	
$37\frac{1}{2}$	
2) 61	sum of two sides
$30\frac{1}{2}$	mean
$29\frac{3}{4}$	True side of equal square
$\frac{3}{4}$	error.

	ft.	in.
Content of a tree 25 feet long, $30\frac{1}{2}$ inches quarter girt,	161	„ 6
Content of a tree 25 feet long, $29\frac{3}{4}$ inches quarter girt,	153	„ 8
Error due to the incorrect method of determining the side of equal square	7	„ 10

Greater side.	Lesser side, 2 in.	Lesser side, 2½ in.	Lesser side, 3 in.	Lesser side, 3½ in.	Lesser side, 4 in.	Lesser side, 4½ in.	Lesser side, 5 in.	Lesser side, 5½ in.	Lesser side, 6 in.	Lesser side, 6½ in.	
	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	
inches.	inches.	inches.	inches	inches.	inches.	inches.	inches.	inches.	inches.	inches.	Greater side.
2½	2¼										
3	2½	2¾									
3½	2¾	3	3¼								
4	2¾	3¼	3½	3¾							
4½	3	3½	3¾	3¾	4¼						
5	3¼	3½	3¾	4	4½	4¾					
5½	3½	3¾	4	4¼	4¾	5	5¼				
6	3½	3¾	4¼	4½	5	5¼	5½	5¾			
6½	3¾	4	4¼	4¾	5	5½	5¾	6	6¼		
7	3¾	4¼	4½	5	5¼	5½	6	6¼	6½	6¾	7
7½	3¾	4¼	4¾	5	5½	5¾	6	6½	6¾	7	7½
8	4	4½	4¾	5¼	5½	6	6¼	6¾	7	7¼	8
8½	4	4½	5	5½	5¾	6¼	6½	6¾	7¼	7½	8½
9	4¼	4¾	5¼	5½	6	6¼	6¾	7	7¼	7¾	9
9½	4¼	4¾	5¼	5¾	6¼	6½	6¾	7¼	7½	7¾	9½
10	4½	5	5½	6	6¼	6¾	7	7½	7¾	8	10
10½	4½	5	5½	6	6½	6¾	7¼	7½	8	8¼	10½
11	4¾	5¼	5¾	6¼	6¾	7	7½	7¾	8	8½	11
11½	4¾	5¼	6	6¼	6¾	7¼	7½	8	8¼	8¾	11½
12	5	5½	6	6½	7	7¼	7¾	8	8½	8¾	12
12½	5	5½	6¼	6½	7	7½	8	8¼	8¾	9	12½
13	5¼	5¾	6¼	6¾	7¼	7¾	8	8½	8¾	9¼	13
13½	5¼	5¾	6¼	7	7¼	7¾	8¼	8½	9	9¼	13½
14	5¼	6	6½	7	7½	8	8¼	8¾	9¼	9½	14
14½	5½	6	6½	7	7½	8	8½	9	9¼	9¾	14½
15	5½	6¼	6¾	7¼	7¾	8¼	8¾	9	9½	10	15
15½	5½	6¼	6¾	7¼	7¾	8¼	8¾	9¼	9¾	10	15½
16	5¾	6¼	7	7½	8	8½	9	9½	9¾	10¼	16
16½	5¾	6½	7	7½	8¼	8½	9¼	9½	10	10¼	16½
17	5¾	6½	7¼	7¾	8¼	8¾	9¼	9¾	10	10½	17
17½	6	6½	7¼	7¾	8¼	8¾	9¼	9¾	10¼	10¾	17½
18	6	6¾	7½	8	8½	9	9½	10	10½	10¾	18

Greater side.	Lesser side, 7 in.	Lesser side. 7½ in.	Lesser side, 8 in.	Lesser side, 8½ in.	Lesser side, 9 in.	Lesser side, 9½ in.	Lesser side. 10 in.	Lesser side, 10½ in.	Lesser side, 11 in.	Lesser side, 11½ in.	
	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	
inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	Greater side.
7½	7¼										
8	7½	7¾									
8½	7¾	8	8¼								
9	**8**	**8¼**	**8½**	**8¾**							
9½	8¼	8½	8¾	9	9¼						
10	8¼	8¾	9	9¼	9½	9¾					
10½	8½	8¾	9¼	9½	9¾	10	10¼				
11	**8¾**	**9**	**9½**	**9¾**	**10**	**10¼**	**10½**	**10¾**			
11½	9	9¼	9½	10	10¼	10½	10¾	11	11¼		
12	9¼	9½	9¾	10	10½	10¾	11	11¼	11½	11¾	12
12½	9¼	9¾	10	10¼	10½	11	11¼	11½	11¾	12	12½
13	**9½**	**9¾**	**10¼**	**10½**	**10¾**	**11**	**11½**	**11¾**	**12**	**12**	**13**
13½	9¾	10	10½	10¾	11	11¼	11½	12	12¼	12¼	13½
14	10	10¼	10½	11	11¼	11½	11¾	12	12½	12½	14
14½	10	10½	10¾	11	11½	11¾	12	12¼	12¾	12¾	14½
15	**10¼**	**10½**	**11**	**11¼**	**11½**	**12**	**12¼**	**12½**	**12¾**	**13**	**15**
15½	10½	10¾	11¼	11½	11¾	12¼	12½	12¾	13	13¼	15½
16	10½	11	11¼	11¾	12	12¼	12¾	13	13¼	13½	16
16½	10¾	11	11½	11¾	12¼	12½	12¾	13¼	13½	13¾	16½
17	**11**	**11¼**	**11¾**	**12**	**12¼**	**12¾**	**13**	**13¼**	**13¾**	**14**	**17**
17½	11	11½	11¾	12¼	12½	13	13¼	13½	13¾	14¼	17½
18	11¼	11½	12	12¼	12¾	13	13½	13¾	14	14½	18
18½	11¼	11¾	12¼	12½	13	13¼	13½	14	14¼	14½	18½
19	**11½**	**12**	**12¼**	**12¾**	**13**	**13½**	**13¾**	**14**	**14½**	**14¾**	**19**
19½	11¾	12	12½	12¾	13¼	13½	14	14¼	14¾	15	19½
20	11¾	12¼	12¾	13	13½	13¾	14¼	14½	14¾	15¼	20
20½	12	12½	12¾	13¼	13½	14	14¼	14¾	15	15¼	20½
21	**12**	**12½**	**13**	**13¼**	**13¾**	**14**	**14½**	**14¾**	**15¼**	**15½**	**21**
21½	12¼	12¾	13	13½	14	14¼	14¾	15	15¼	15¾	21½
22	12½	12¾	13¼	13¾	14	14½	14¾	15¼	15½	16	22
22½	12½	13	13½	13¾	14¼	14½	15	15¼	15¾	16	22½
23	**12¾**	**13**	**13½**	**14**	**14½**	**14¾**	**15¼**	**15½**	**16**	**16¼**	**23**

Greater side.	Lesser side, 12 in.	Lesser side, 12½ in.	Lesser side, 13 in.	Lesser side, 13½ in.	Lesser side, 14 in.	Lesser side, 14½ in.	Lesser side, 15 in.	Lesser side, 15½ in.	Lesser side, 16 in.	Lesser side, 16½ in.	
	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square	Side of equal square.	
inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	Greater side.
12½	12¼										
13	12½	12¾									
13½	12¾	13	13¼								
14	**13**	**13¼**	**13½**	**13¾**							
14½	13¼	13½	13¾	14	14¼						
15	13½	13¾	14	14¼	14½	14¾					
15½	13¾	14	14¼	14½	14¾	15	15¼				
16	**13¾**	**14¼**	**14½**	**14¾**	**15**	**15¼**	**15½**	**15¾**			
16½	14	14¼	14¾	15	15¼	15½	15¾	16	16¼		
17	14¼	14½	14¾	15¼	15½	15¾	16	16¼	16½	16¾	17
17½	14½	14¾	15	15¼	15¾	16	16¼	16½	16¾	17	17½
18	**14¾**	**15**	**15¼**	**15½**	**16**	**16¼**	**16½**	**16¾**	**17**	**17¼**	**18**
18½	15	15	15½	15¾	16¼	16½	16¾	17	17¼	17½	18½
19	15	15¼	15½	16	16½	16½	17	17¼	17½	17¾	19
19½	15¼	15½	15¾	16¼	16¾	16¾	17	17½	17¾	18	19½
20	**15½**	**15¾**	**16**	**16½**	**16¾**	**17**	**17¼**	**17½**	**18**	**18¼**	**20**
20½	15¾	16	16¼	16¾	17	17¼	17½	17¾	18	18½	20½
21	15¾	16¼	16½	16¾	17¼	17½	17¾	18	18¼	18½	21
21½	16	16½	16¾	17	17¼	17¾	18	18¼	18¼	18¾	21½
22	**16¼**	**16½**	**17**	**17¼**	**17½**	**17¾**	**18¼**	**18½**	**18¾**	**19**	**22**
22½	16½	16¾	17	17½	17¾	18	18¼	18¾	19	19¼	22½
23	16¾	17	17¼	17½	18	18¼	18½	18¾	19¼	19½	23
23½	16¾	17	17½	17¾	18¼	18½	18¾	19	19½	19¾	23½
24	**17**	**17¼**	**17¾**	**18**	**18¼**	**18¾**	**19**	**19¼**	**19½**	**20**	**24**
24½	17¼	17½	17¾	18¼	18½	18¾	19¼	19½	19¾	20	24½
25	17¼	17¾	18	18 ¼	18¾	19	19¼	19¾	20	20¼	25
25½	17½	18	18¼	18½	19	19¼	19½	19¾	20¼	20½	25½
26	**17¾**	**18**	**18½**	**18¾**	**19**	**19½**	**19¾**	**20**	**20½**	**20¾**	**26**
26½	17¾	18¼	18½	19	19⅓	19½	20	20¼	20½	20¾	26½
27	18	18½	18¾	19	19½	19¾	20¼	20½	20¾	21	27
27½	18¼	18½	19	19¼	19½	20	20¼	20¾	21	21¼	27½
28	**18¼**	**18¾**	**19**	**19½**	**19¾**	**20¼**	**20½**	**20¾**	**21¼**	**21½**	**28**

Greater side.	Lesser side, 17 in.	Lesser side. 17½ in.	Lesser side, 18 in.	Lesser side, 18½ in.	Lesser side, 19 in.	Lesser side, 19½ in.	Lesser side. 20 in.	Lesser side, 20½ in.	Lesser side, 21 in.	Lesser side, 21½ in.	Greater side.
	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	
inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	
17½	17¼										
18	17½	17¾									
18½	17¾	18	18¼								
19	**18**	**18¼**	**18½**	**18¾**							
19½	18¼	18½	18¾	19	19¼						
20	18½	18¾	19	19¼	19½	19¾					
20½	18¾	19	19¼	19½	19¾	20	20¼				
21	**19**	**19¼**	**19½**	**19¾**	**20**	**20¼**	**20½**	**20¾**			
21½	19	19½	19¾	20	20¼	20½	20¾	21	21¼		
22	19¼	19½	20	20¼	20½	20¾	21	21¼	21½	21¾	22
22½	19½	19¾	20¼	20½	20¾	21	21¼	21½	21¾	22	22½
23	**19¾**	**20**	**20¼**	**20¾**	**21**	**21¼**	**21½**	**21¾**	**22**	**22¼**	**23**
23½	20	20¼	20½	20¾	21¼	21½	21¾	22	22¼	22½	23½
24	20¼	20½	20¾	21	21¼	21¾	22	22¼	22½	22¾	24
24½	20½	20¾	21	21¼	21½	21¾	22¼	22½	22¾	23	24½
25	**20½**	**21**	**21¼**	**21½**	**21¾**	**22**	**22¼**	**22¾**	**23**	**23¼**	**25**
25½	20¾	21	21½	21¾	22	22¼	22½	22¾	23¼	23½	25½
26	21	21¼	21½	22	22¼	22½	22¾	23	23¼	23¾	26
26½	21¼	21½	21¾	22¼	22½	22¾	23	23¼	23½	23¾	26½
27	**21½**	**21¾**	**22**	**22¼**	**22¾**	**23**	**23¼**	**23½**	**23¾**	**24**	**27**
27½	21½	22	22¼	22½	22¾	23¼	23½	23¾	24	24¼	27½
28	21¾	22¼	22½	22¾	23	23¼	23¾	24	24¼	24½	28
28½	22	22¼	22¾	23	23¼	23½	23¾	24¼	24½	24¾	28½
29	**22¼**	**22½**	**22¾**	**23¼**	**23½**	**23¾**	**24**	**24¼**	**24¾**	**25**	**29**
29½	22½	22¾	23	23¼	23¾	24	24¼	24½	25	25¼	29½
30	22½	23	23¼	23½	23¾	24¼	24½	24¾	25	25½	30
30½	22¾	23	23½	23¾	24	24½	24¾	25	25¼	25½	30½
31	**23**	**23¼**	**23½**	**24**	**24¼**	**24½**	**25**	**25¼**	**25½**	**25¾**	**31**
31½	23¼	23½	23¾	24¼	24½	24¾	25	25½	25¾	26	31½
32	23¼	23¾	24	24¼	24¾	25	25¼	25½	26	26¼	32
32½	23½	23¾	24¼	24½	24¾	25¼	25½	25¾	26	26½	32½
33	**23¾**	**24**	**24½**	**24¾**	**25**	**25¼**	**25¾**	**26**	**26¼**	**26¾**	**33**

Greater side.	Lesser side, 22 in.	Lesser side, 22½ in.	Lesser side, 23 in.	Lesser side, 23½ in.	Lesser side, 24 in.	Lesser side, 24½ in.	Lesser side, 25 in.	Lesser side, 25½ in.	Lesser side, 26 in.	Lesser side, 26½ in.	Greater side.
	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	
inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	
22½	22¼										
23	22½	22¾									
23½	22¾	23	23¼								
24	23	23¼	23½	23¾							
24½	23¼	23½	23¾	24	24¼						
25	23½	23¾	24	24¼	24½	24¾					
25½	23¾	24	24¼	24½	24¾	25	25¼				
26	24	24¼	24½	24¾	25	25¼	25½	25¾			
26½	24¼	24½	24¾	25	25¼	25½	25¾	26	26¼		
27	24½	24¾	25	25¼	25½	25¾	26	26¼	26½	26¾	27
27½	24½	24¾	25¼	25½	25¾	26	26¼	26½	26¾	27	27½
28	24¾	25	25½	25¾	26	26¼	26½	26¾	27	27¼	28
28½	25	25¼	25½	25¾	26¼	26½	26¾	27	27¼	27½	28½
29	25¼	25½	25¾	26	26¼	26¾	27	27¼	27½	27¾	29
29½	25½	25¾	26	26¼	26½	27	27¼	27½	27¾	28	29½
30	25¾	26	26¼	26½	26¾	27	27¼	27¾	28	28¼	30
30½	26	26¼	26½	26¾	27	27¼	27½	27¾	28¼	28½	30½
31	26	26½	26¾	27	27¼	27½	27¾	28	28¼	28¾	31
31½	26¼	26½	27	27¼	27½	27¾	28	28¼	28½	28¾	31½
32	26½	26¾	27¼	27½	27¾	28	28¼	28½	28¾	29	32
32½	26¾	27	27¼	27¾	28	28¼	28½	28¾	29	29¼	32½
33	27	27¼	27½	27¾	28¼	28½	28¾	29	29¼	29½	33
33½	27¼	27½	27¾	28	28¼	28¾	29	29¼	29½	29¾	33½
34	27½	27¾	28	28¼	28½	28¾	29¼	29½	29¾	30	34
34½	27½	27¾	28¼	28½	28¾	29	29¼	29¾	30	30¼	34½
35	27¾	28	28¼	28¾	29	29¼	29½	29¾	30¼	30½	35
35½	28	28¼	28½	29	29¼	29½	29¾	30	30½	30¾	35½
36	28¼	28½	28¾	29	29½	29¾	30	30¼	30½	31	36
36½	28¼	28¾	29	29¼	29½	30	30¼	30½	30¾	31	36½
37	28½	28¾	29¼	29½	29¾	30	30½	30¾	31	31¼	37
37½	28¾	29	29¼	29¾	30	30¼	30½	31	31¼	31½	37½
38	29	29¼	29½	29¾	30½	30½	30¾	31¼	31½	31¾	38

Greater side.	Lesser side, 27 in.	Lesser side, 27½ in.	Lesser side, 28 in.	Lesser side, 28½ in.	Lesser side, 29 in.	Lesser side, 29½ in.	Lesser side, 30 in.	Lesser side, 30½ in.	Lesser side, 31 in.	Lesser side, 31½ in.	
	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square	
Inches.	Inches	inches.	inches	inches.	inches.	inches.	inches.	inches.	inches.	inches.	Greater side.
27½	27¼										
28	27½	27¾									
28½	27¾	28	28¼								
29	**28**	**28¼**	**28½**	**28¾**							
29½	28¼	28½	28¾	29	29¼						
30	28½	28¾	29	29¼	29½	29¾					
30½	28¾	29	29¼	29½	29¾	30	30¼				
31	**29**	**29¼**	**29½**	**29¾**	**30**	**30¼**	**30½**	**30¾**			
31½	29¼	29½	29¾	30	30¼	30½	30¾	31	31¼		
32	29½	29¾	30	30¼	30½	30¾	31	31¼	31½	31¾	32
32½	29½	29¾	30¼	30½	30¾	31	31¼	31½	31¾	32	32½
33	**29¾**	**30**	**30½**	**30¾**	**31**	**31¼**	**31½**	**31¾**	**32**	**32½**	**33**
33½	30	30¼	30¾	31	31¼	31½	31¾	32	32¼	32½	33½
34	30¼	30½	30¾	31¼	31½	31¾	32	32¼	32½	32¾	34
34½	30½	30¾	31	31¼	31¾	32	32¼	32½	32¾	33	34½
35	**30¾**	**31**	**31¼**	**31½**	**31¾**	**32**	**32½**	**32¾**	**33**	**33½**	**35**
35½	31	31¼	31½	31¾	32	32¼	32¾	33	33¼	33½	35½
36	31¼	31½	31¾	32	32¼	32½	32¾	33¼	33½	33¾	36
36½	31½	31¾	32	32¼	32½	32¾	33	33¼	33½	34	36½
37	**31½**	**32**	**32¼**	**32½**	**32¾**	**33**	**33¼**	**33½**	**33¾**	**34¼**	**37**
37½	31¾	32	32½	32¾	33	33¼	33½	33¾	34	34¼	37½
38	32	32¼	32½	33	33¼	33½	33¾	34	34¼	34½	38
38½	32¼	32½	32¾	33	33½	33¾	34	34¼	34½	34¾	38½
39	**32½**	**32¾**	**33**	**33¼**	**33¾**	**34**	**34¼**	**34½**	**34¾**	**35**	**39**
39½	32¾	33	33¼	33½	33¾	34¼	34½	34¾	35	35¼	39½
40	32¾	33¼	33½	33¾	34	34¼	34¾	35	35¼	35½	40
40½	33	33¼	33¾	34	34¼	34½	34¾	35¼	35½	35¾	40½
41	**33¼**	**33½**	**34**	**34¼**	**34½**	**34¾**	**35**	**35¼**	**35¾**	**36**	**41**
41½	33½	33¾	34	34½	34¾	35	35¼	35½	35¾	36¼	41½
42	33¾	34	34¼	34½	35	35¼	35½	35¾	36	36¼	42
42½	33¾	34¼	34½	34¾	35	35½	35¾	36	36¼	36½	42½
43	**34**	**34½**	**34¾**	**35**	**35½**	**35½**	**36**	**36¼**	**36½**	**36¾**	**43**

Greater side	Lesser side, 32 in.	Lesser side, 32½ in.	Lesser side, 33 in.	Lesser side, 33½ in.	Lesser side, 34 in.	Lesser side, 34½ in.	Lesser side, 35 in.	Lesser side, 35½ in.	Lesser side, 36 in.	Lesser side, 36½ in.	Greater side
	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	
inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	
32½	32¼										
33	32½	32¾									
33½	32¾	33	33¼								
34	**33**	**33¼**	**33½**	**33¾**							
34½	33¼	33½	33¾	34	34¼						
35	33½	33¾	34	34¼	34½	34¾					
35½	33¾	34	34¼	34½	34¾	35	35¼				
36	**34**	**34¼**	**34½**	**34¾**	**35**	**35¼**	**35½**	**35¾**			
36½	34¼	34½	34¾	35	35¼	35½	35¾	36	36¼		
37	34½	34¾	35	35¼	35½	35¾	36	36¼	36½	36¾	37
37½	34¾	35	35¼	35½	35¾	36	36¼	36½	36¾	37	37½
38	**34¾**	**35¼**	**35½**	**35¾**	**35¾**	**36¼**	**36½**	**36¾**	**37**	**37¼**	**38**
38½	35	35½	35¾	36	36	36½	36¾	37	37¼	37½	38½
39	35¼	35½	35¾	36¼	36¼	36¾	37	37¼	37½	37¾	39
39½	35½	35¾	36	36½	36½	37	37¼	37½	37¾	38	39½
40	**35¾**	**36**	**36¼**	**36½**	**36¾**	**37¼**	**37½**	**37¾**	**38**	**38¼**	**40**
40½	36	36¼	36½	36¾	37	37½	37¾	38	38¼	38½	40½
41	36¼	36½	36¾	37	37¼	37½	38	38¼	38½	38¾	41
41½	36½	36¾	37	37¼	37½	37¾	38	38¼	38¾	39	41½
42	**36¾**	**37**	**37¼**	**37½**	**37¾**	**38**	**38¼**	**38½**	**39**	**39¼**	**42**
42½	37	37¼	37½	37¾	38	38¼	38½	38¾	39	39½	42½
43	37	37½	37¾	38	38	38½	38¾	39	39¼	39½	43
43½	37¼	37½	38	38¼	38¼	38¾	39	39¼	39½	39¾	43½
44	**37½**	**37¾**	**38**	**38½**	**38½**	**39**	**39¼**	**39½**	**39¾**	**40**	**44**
44½	37¾	38	38¼	38½	38¾	39¼	39½	39¾	40	40¼	44½
45	38	38¼	38½	38¾	39	39½	39¾	40	40¼	40½	45
45½	38¼	38½	38½	39	39¼	39½	40	40¼	40½	40¾	45½
46	**38¼**	**38¾**	**38¾**	**39¼**	**39½**	**39¾**	**40**	**40½**	**40¾**	**41**	**46**
46½	38½	38¾	39	39½	39¾	40	40¼	40½	41	41¼	46½
47	38¾	39	39¼	39¾	40	40¼	40½	43¾	41¼	41½	47
47½	39	39¼	39½	40	40¼	40½	40¾	41	41½	41¾	47½
48	**39¼**	**39½**	**39¾**	**40**	**40½**	**40¾**	**41**	**41¼**	**41½**	**41¾**	**48**

Greater size.	Lesser side, 37 in.	Lesser side, 37½ in.	Lesser side, 38 in.	Lesser side, 38½ in.	Lesser side, 39 in.	Lesser side, 39½ in.	Lesser side, 40 in.	Lesser side, 40½ in.	Lesser side. 41 in.	Lesser side, 41½ in.	
	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	
inches.	inches.	inches	inches.	inches.	inches.	inches.	inches.	Inches.	inches.	inches.	Greater side.
37½	37¼										
38	37½	37¾									
38½	37¾	38	38¼								
39	**38**	**38¼**	**38½**	**38¾**							
39½	38¼	38½	38¾	39	39¼						
40	38½	38¾	39	39¼	39½	39¾					
40½	38¾	39	39¼	39½	39¾	**40**	40¼				
41	**39**	**39¼**	**39½**	**39¾**	**40**	**40¼**	**40½**	**40¾**			
41½	39¼	39½	39¾	40	40¼	40½	40¾	41	41⅛		
42	39½	39¾	40	40¼	40½	40¾	41	41¼	41½	41¾	42
42½	39¾	40	40¼	40½	40¾	41	41¼	41½	41¾	42	42½
43	**40**	**40¼**	**40½**	**40¾**	**41**	**41¼**	**41½**	**41¾**	**42**	**42¼**	**43**
43½	40	40½	40¾	41	41¼	41½	41¾	42	42⅛	42½	43½
44	40¼	40¾	41	41¼	41½	41¾	42	42¼	42½	42¾	44
44½	40½	40¾	41	41½	41¾	42	42¼	42½	42¾	43	44½
45	**40¾**	**41**	**41¼**	**41½**	**42**	**42¼**	**42½**	**42¾**	**43**	**43¼**	**45**
45½	41	41¼	41½	41¾	42	42¼	42¾	43	43⅛	43½	45½
46	41¼	41½	41¾	42	42¼	42½	43	43¼	43½	43¾	46
46½	41½	41¾	42	42¼	42½	42¾	43¼	43½	43¾	44	46½
47	**41¾**	**42**	**42¼**	**42½**	**42¾**	**43**	**43¼**	**43½**	**44**	**44¼**	**47**
47½	42	42¼	42½	42¾	43	43¼	43½	43¾	44⅛	44½	47½
48	42¼	42½	42¾	43	43¼	43½	43¾	44	44¼	44¾	48
48½	42¼	42¾	43¼	43¼	43½	43¾	44	44¼	44½	44¾	48½
49	**42½**	**42¾**	**43**	**43½**	**43¾**	**44**	**44¼**	**44½**	**44¾**	**45**	**49**
49½	42¾	43	43¼	43¼	44	44¼	44½	44¾	45	45¼	49½
50	43	43¼	43½	43¾	44¼	44½	44¾	45	45¼	45½	50
50½	43¼	43½	43¾	44	44¼	44¾	45	45¼	45½	45¾	50½
51	**43½**	**43¾**	**44**	**44¼**	**44½**	**45**	**45¼**	**45½**	**45¼**	**46**	**51**
51½	43¾	44	44¼	44½	44¾	45	45½	45¾	46	46¼	51½
52	43¾	44¼	44½	44¾	45	45¼	45½	46	46¼	46½	52
52½	44	44¼	44¾	45	45¼	45½	45¾	46	46½	46¾	52½
53	**44¼**	**44½**	**44¾**	**45¼**	**45½**	**45¾**	**46**	**46¼**	**46½**	**47**	**53**

Greater side.	Lesser side, 42 in.	Lesser side, 42½ in.	Lesser side, 43 in.	Lesser side, 43½ in.	Lesser side, 44 in.	Lesser side, 44½ in.	Lesser side, 45 in.	Lesser side, 45½ in.	Lesser side, 46 in.	Lesser side, 46½ in.	
	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	
inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	
42½	42¼										
43	42½	42¾									
43½	42¾	43	43¼								
44	43	43¼	43½	43¾							
44½	43¼	43½	43¾	44	44¼						
45	43½	43¾	44	44¼	44½	44¾					
45½	43¾	44	44¼	44½	44¾	45	45¼				
46	44	44¼	44½	44¾	45	45¼	45½	45¾			
46½	44¼	44½	44¾	45	45¼	45½	45¾	46	46¼		
47	44½	44¾	45	45¼	45½	45¾	46	46¼	46½	46¾	47
47½	44¾	45	45¼	45½	45¾	46	46¼	46½	46¾	47	47½
48	45	45¼	45½	45¾	46	46¼	46½	46¾	47	47¼	48
48½	45¼	45½	45¾	46	46¼	46½	46¾	47	47¼	47½	48½
49	45¼	45½	46	46¼	46½	46¾	47	47¼	47½	47¾	49
49½	45½	45¾	46¼	46½	46¾	47	47¼	47½	47¾	48	49½
50	45¾	46	46¼	46¾	47	47¼	47½	47¾	48	48¼	50
50½	46	46¼	46½	46¾	47¼	47½	47¾	48	48¼	48½	50½
51	46¼	46½	46¾	47	47¼	47¾	48	48¼	48½	48¾	51
51½	46½	46¾	47	47¼	47½	47¾	48¼	48½	48¾	49	51½
52	46¾	47	47¼	47½	47¾	48	48¼	48¾	49	49¼	52
52½	47	47¼	47½	47¾	48	48¼	48½	48¾	49	49½	52½
53	47¼	47½	47¾	48	48¼	48½	48¾	49	49¼	49¾	53
53½	47½	47¾	48	48¼	48½	48¾	49	49¼	49½	49¾	53½
54	47½	48	48¼	48½	48¾	49	49¼	49½	49¾	50	54

Greater side.
47
47½
48
48½
49
49½
50
50½
51
51½
52
52½
53
53½
54

Greater side.	Lesser side, 47 in.	Lesser side, 47½ in.	Lesser side, 48 in.	Lesser side, 48½ in.	Lesser side, 49 in.	Lesser side, 49½ in.	Lesser side, 50 in.	Lesser side, 50½ in.	Lesser side, 51 in.	Lesser side, 51½ in.	Greater side.
	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	
inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	
47½	47¼										
48	47½	47¾									
48½	47¾	48	48¼								
49	**48**	**48¼**	**48½**	**48¾**							
49½	48¼	48½	48¾	49	49¼						
50	48½	48¾	49	49¼	49½	49¾					
50½	48¾	49	49¼	49½	49¾	50	50¼				
51	**49**	**49¼**	**49½**	**49¾**	**50**	**50¼**	**50½**	**50¾**			
51½	49¼	49½	49¾	50	50¼	50½	50¾	51	51¼		
52	49½	49¾	50	50¼	50½	50¾	51	51¼	51½	51¾	52
52½	49¾	50	50¼	50½	50¾	51	51¼	51½	51¾	52	52½
53	**50**	**50¼**	**50½**	**50¾**	**51**	**51¼**	**51½**	**51¾**	**52**	**52¼**	**53**
53½	50¼	50½	50¾	51	51¼	51½	51¾	52	52¼	52½	53½
54	**50½**	**50¾**	**51**	**51¼**	**51½**	**51¾**	**52**	**52¼**	**52½**	**52¾**	**54**

Greater side.	Lesser side, 52 in.	Lesser side, 52½ in.	Lesser side, 53 in.	Lesser side, 53½ in.	Lesser side, 54 in.
	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.	Side of equal square.
inches.	inches.	inches.	inches.	inches.	inches.
52½	52¼				
53	52½	52¾			
53½	52¾	53	53¼		
54	**53**	**53¼**	**53½**	**53¾**	**54**

TIMBER TABLES, No. III.

Tables of Superficial or Flat Measure.

These Tables commence with 1 inch in width, and extend by the progressive addition of an inch up to 2 feet, and from thence by the addition of 2 inches up to 10 feet.

The first and fifth columns contain the lengths from 1 inch to 30 feet. The remaining columns contain the superficial contents due to any given length and width, the columns of which intersect each other in the positions in which such quantities severally stand.

The use of the Tables is too obvious to require comment.

Ex. 1.—Required the superficial content of a board 19 feet long and 16 inches broad.

In page 531, opposite 19 feet long, and under 1 foot 4 inches broad, stands 25 feet 4 inches, the content required.

Ex. 2. The side of a room 9 feet 10 inches high, is 26 feet 7 inches, what is its superficial content?

In page 540, under 9 ft. 10 in. broad and opposite

Ft.	In.		Ft.	In.	
26	0	is	255	8	
0	7	is	5	8	
26	7		261	4	Required content.

Lengths.		1 inch wide.		2 inches wide.		3 inches wide.		Lengths.		4 inches wide.		5 inches wide.		6 inches wide.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
0	1	0	0	0	0	0	¼	0	1	0	¼	0	¼	0	½
0	2	0	0	0	¼	0	½	0	2	0	½	0	¾	0	1
0	3	0	¼	0	¼	0	¾	0	3	0	1	0	1	0	1
0	4	0	¼	0	½	0	1	0	4	0	1	0	1	0	2
0	5	0	¼	0	½	0	1	0	5	0	1	0	2	0	2
0	**6**	**0**	**½**	**0**	**1**	**0**	**1**	**0**	**6**	**0**	**2**	**0**	**2**	**0**	**3**
0	7	0	½	0	1	0	1	0	7	0	2	0	2	0	3
0	8	0	½	0	1	0	2	0	8	0	2	0	3	0	4
0	9	0	¾	0	1	0	2	0	9	0	3	0	3	0	4
0	10	0	¾	0	1	0	2	0	10	0	3	0	4	0	5
0	**11**	**0**	**¾**	**0**	**1**	**0**	**2**	**0**	**11**	**0**	**3**	**0**	**4**	**0**	**5**
1	0	0	1	0	2	0	3	1	0	0	4	0	5	0	6
2	0	0	2	0	4	0	6	2	0	0	8	0	10	1	0
3	0	0	3	0	6	0	9	3	0	1	0	1	3	1	6
4	0	0	4	0	8	1	0	4	0	1	4	1	8	2	0
5	**0**	**0**	**5**	**0**	**10**	**1**	**3**	**5**	**0**	**2**	**8**	**2**	**1**	**2**	**6**
6	0	0	6	1	0	1	6	6	0	2	0	2	6	3	0
7	0	0	7	1	2	1	9	7	0	2	4	2	11	3	6
8	0	0	8	1	4	2	0	8	0	2	8	3	4	4	0
9	0	0	9	1	6	2	3	9	0	3	0	3	9	4	6
10	**0**	**0**	**10**	**1**	**8**	**2**	**6**	**10**	**0**	**3**	**4**	**4**	**2**	**5**	**0**
11	0	0	11	1	10	2	9	11	0	3	8	4	7	5	6
12	0	1	0	2	0	3	0	12	0	4	0	5	0	6	0
13	0	1	1	2	2	3	3	13	0	4	4	5	5	6	6
14	0	1	2	2	4	3	6	14	0	4	8	5	10	7	0
15	**0**	**1**	**3**	**2**	**6**	**3**	**9**	**15**	**0**	**5**	**0**	**6**	**3**	**7**	**6**
16	0	1	4	2	8	4	0	16	0	5	4	6	8	8	0
17	0	1	5	2	10	4	3	17	0	5	8	7	1	8	6
18	0	1	6	3	0	4	6	18	0	6	0	7	6	9	0
19	0	1	7	3	2	4	9	19	0	6	4	7	11	9	6
20	**0**	**1**	**8**	**3**	**4**	**5**	**0**	**20**	**0**	**6**	**8**	**8**	**4**	**10**	**0**
21	0	1	9	3	6	5	3	21	0	7	0	8	9	10	6
22	0	1	10	3	8	5	6	22	0	7	4	9	2	11	0
23	0	1	11	3	10	5	9	23	0	7	8	9	7	11	6
24	0	2	0	4	0	6	0	24	0	8	0	10	0	12	0
25	**0**	**2**	**1**	**4**	**2**	**6**	**3**	**25**	**0**	**8**	**4**	**10**	**5**	**12**	**6**
26	0	2	2	4	4	6	6	26	0	8	8	10	10	13	0
27	0	2	3	4	6	6	9	27	0	9	0	11	3	13	6
28	0	2	4	4	8	7	0	28	0	9	4	11	8	14	0
29	0	2	5	4	10	7	3	29	0	9	8	12	1	14	6
30	**0**	**2**	**6**	**5**	**0**	**7**	**6**	**30**	**0**	**10**	**0**	**12**	**6**	**15**	**0**

Lengths.		7 inches wide.		8 inches wide.		9 inches wide.		Lengths.		10 inches wide.		11 inches wide.		12 inches wide.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
0	1	0	½	0	½	0	¾	0	1	0	¾	0	¾	0	1
0	2	0	1	0	1	0	1	0	2	0	1	0	1	0	2
0	3	0	1	0	2	0	2	0	3	0	2	0	2	0	3
0	4	0	2	0	2	0	3	0	4	0	3	0	3	0	4
0	5	0	2	0	3	0	3	0	5	0	4	0	4	0	5
0	**6**	**0**	**3**	**0**	**4**	**0**	**4**	**0**	**6**	**0**	**5**	**0**	**5**	**0**	**6**
0	7	0	4	0	4	0	5	0	7	0	5	0	6	0	7
0	8	0	4	0	5	0	6	0	8	0	6	0	7	0	8
0	9	0	5	0	6	0	6	0	9	0	7	0	8	0	9
0	10	0	5	0	6	0	7	0	10	0	8	0	9	0	10
0	**11**	**0**	**6**	**0**	**7**	**0**	**8**	**0**	**11**	**0**	**9**	**0**	**10**	**0**	**11**
1	0	0	7	0	8	0	9	1	0	0	10	0	11	1	0
2		1	2	1	4	1	6	2	0	1	8	1	10	2	0
3		1	9	2	0	2	3	3	0	2	6	2	9	3	0
4		2	4	2	8	3	0	4	0	3	4	3	8	4	0
5		**2**	**11**	**3**	**4**	**3**	**9**	**5**	**0**	**4**	**2**	**4**	**7**	**5**	**0**
6	0	3	6	4	0	4	6	6	0	5	0	5	6.	6	0
7	0	4	1	4	8	5	3	7	0	5	10	6	5	7	0
8	0	4	8	5	4	6	0	8	0	6	8	7	4	8	0
9	0	5	3	6	0	6	9	9	0	7	6	8	3	9	0
10	**0**	**5**	**10**	**6**	**8**	**7**	**6**	**10**	**0**	**8**	**4**	**9**	**2**	**10**	**0**
11	0	6	5	7	4	8	3	11	0	9	2	10	1	11	0
12	0	7	0	8	0	9	0	12	0	10	0	11	0	12	0
13	0	7	7	8	8	9	9	13	0	10	10	11	11	13	0
14	0	8	2	9	4	10	6	14	0	11	8	12	10	14	0
15	**0**	**8**	**9**	**10**	**0**	**11**	**3**	**15**	**0**	**12**	**6**	**13**	**9**	**15**	**0**
16	0	9	4	10	8	12	0	16	0	13	4	14	8	16	0
17	0	9	11	11	4	12	9	17	0	14	2	15	7	17	0
18	0	10	6	12	0	13	6	18	0	15	0	16	6	18	0
19	0	11	1	12	8	14	3	19	0	15	10	17	5	19	0
20	**0**	**11**	**8**	**13**	**4**	**15**	**0**	**20**	**0**	**16**	**8**	**18**	**4**	**20**	**0**
21	0	12	3	14	0	15	9	21	0	17	6	19	3	21	0
22	0	12	10	14	8	16	6	22	0	18	4	20	2	22	0
23	0	13	5	15	4	17	3	23	0	19	2	21	1	23	0
24	0	14	0	16	0	18	0	24	0	20	0	22	0	24	0
25	**0**	**14**	**7**	**16**	**8**	**18**	**9**	**25**	**0**	**20**	**10**	**22**	**11**	**25**	**0**
26	0	15	2	17	4	19	6	26	0	21	8	23	10	26	0
27	0	15	9	18	0	20	3	27	0	22	6	24	9	27	0
28	0	16	4	18	8	21	0	28	0	23	4	25	8	28	0
29	0	16	11	19	4	21	9	29	0	24	2	26	7	29	0
30	**0**	**17**	**6**	**20**	**0**	**22**	**6**	**30**	**0**	**25**	**0**	**27**	**6**	**30**	**0**

Lengths.		1ft. 1in. wide.		1ft. 2in. wide.		1ft. 3in. wide.		Lengths.		1ft. 4in. wide.		1ft. 5in. wide.		1ft. 6in. wide.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	3
0	3	0	3	0	3	0	3	0	3	0	4	0	4	0	4
0	4	0	4	0	4	0	4	0	4	0	5	0	5	0	6
0	5	0	5	0	5	0	5	0	5	0	6	0	7	0	7
0	**6**	**0**	**6**	**0**	**7**	**0**	**7**	**0**	**6**	**0**	**8**	**0**	**8**	**0**	**9**
0	7	0	7	0	8	0	8	0	7	0	9	0	9	0	10
0	8	0	8	0	9	0	9	0	8	0	10	0	11	1	0
0	9	0	9	0	10	0	11	0	9	1	0	1	0	1	1
0	10	0	10	0	11	1	0	0	10	1	1	1	2	1	3
0	**11**	**0**	**11**	**1**	**0**	**1**	**1**	**0**	**11**	**1**	**2**	**1**	**3**	**1**	**4**
1	0	1	1	1	2	1	3	1	0	1	4	1	5	1	6
2	0	2	2	2	4	2	6	2	0	2	8	2	10	3	0
3	0	3	3	3	6	3	9	3	0	4	0	4	3	4	6
4	0	4	4	4	8	5	0	4	0	5	4	5	8	6	0
5	**0**	**5**	**5**	**5**	**10**	**6**	**3**	**5**	**0**	**6**	**8**	**7**	**1**	**7**	**6**
6	0	6	6	7	0	7	6	6	0	8	0	8	6	9	0
7	0	7	7	8	2	8	9	7	0	9	4	9	11	10	6
8	0	8	8	9	4	10	0	8	0	10	8	11	4	12	0
9	0	9	9	10	6	11	3	9	0	12	0	12	9	13	6
10	**0**	**10**	**10**	**11**	**8**	**12**	**6**	**10**	**0**	**13**	**4**	**14**	**2**	**15**	**0**
11	0	11	11	12	10	13	9	11	0	14	8	15	7	16	6
12	0	13	0	14	0	15	0	12	0	16	0	17	0	18	0
13	0	14	1	15	2	16	3	13	0	17	4	18	5	19	6
14	0	15	2	16	4	17	6	14	0	18	8	19	10	21	0
15	**0**	**16**	**3**	**17**	**6**	**18**	**9**	**15**	**0**	**20**	**0**	**21**	**3**	**22**	**6**
16	0	17	4	18	8	20	0	16	0	21	4	22	8	24	0
17	0	18	5	19	10	21	3	17	0	22	8	24	1	25	6
18	0	19	6	21	0	22	6	18	0	24	0	25	6	27	0
19	0	20	7	22	2	23	9	19	0	25	4	26	11	28	6
20	**0**	**21**	**8**	**23**	**4**	**25**	**0**	**20**	**0**	**26**	**8**	**28**	**4**	**30**	**0**
21	0	22	9	24	6	26	3	21	0	28	0	29	9	31	6
22	0	23	10	25	8	27	6	22	0	29	4	31	2	33	0
23	0	24	11	26	10	28	9	23	0	30	8	32	7	34	6
24	0	26	0	28	0	30	0	24	0	32	0	34	0	36	0
25	**0**	**27**	**1**	**29**	**2**	**31**	**3**	**25**	**0**	**33**	**4**	**35**	**5**	**37**	**6**
26	0	28	2	30	4	32	6	26	0	34	8	36	10	39	0
27	0	29	3	31	6	33	9	27	0	36	0	38	3	40	6
28	0	30	4	32	8	35	0	28	0	37	4	39	8	42	0
29	0	31	5	33	10	36	3	29	0	38	8	41	1	43	6
30	**0**	**32**	**6**	**35**	**0**	**37**	**6**	**30**	**0**	**40**	**0**	**42**	**6**	**45**	**0**

Lengths.		1ft. 7in. wide.		1ft. 8in. wide.		1ft. 9in. wide.		Lengths.		1ft. 10in. wide.		1ft. 11in. wide.		2ft. 0in. wide.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	2
0	2	0	3	0	3	0	3	0	2	0	3	0	3	0	4
0	3	0	4	0	5	0	5	0	3	0	5	0	5	0	6
0	4	0	6	0	6	0	7	0	4	0	7	0	7	0	8
0	5	0	7	0	8	0	8	0	5	0	9	0	9	0	10
0	**6**	**0**	**9**	**0**	**10**	**0**	**10**	**0**	**6**	**0**	**11**	**0**	**11**	**1**	**0**
0	7	0	11	0	11	1	0	0	7	1	0	1	1	1	2
0	8	1	0	1	1	1	2	0	8	1	2	1	3	1	4
0	9	1	2	1	3	1	3	9	9	1	4	1	5	1	6
0	10	1	3	1	4	1	5	0	10	1	6	1	7	1	8
0	**11**	**1**	**5**	**1**	**6**	**1**	**7**	**0**	**11**	**1**	**8**	**1**	**9**	**1**	**10**
1	0	1	7	1	8	1	9	1	0	1	10	1	11	2	0
2	0	3	2	3	4	3	6	2	0	3	8	3	10	4	0
3	0	4	9	5	0	5	3	3	0	5	6	5	9	6	0
4	0	6	4	6	8	7	0	4	0	7	4	7	8	8	0
5	**0**	**7**	**11**	**8**	**4**	**8**	**9**	**5**	**0**	**9**	**2**	**9**	**7**	**10**	**0**
6	0	9	6	10	0	10	6	6	0	11	0	11	6	12	0
7	0	11	1	11	8	12	3	7	0	12	10	13	5	14	0
8	0	12	8	13	4	14	0	8	0	14	8	15	4	16	0
9	0	14	3	15	0	15	9	9	0	16	6	17	3	18	0
10	**0**	**15**	**10**	**16**	**8**	**17**	**6**	**10**	**0**	**18**	**4**	**19**	**2**	**20**	**0**
11	0	17	5	18	4	19	3	11	0	20	2	21	1	22	0
12	0	19	0	20	0	21	0	12	0	22	0	23	0	24	0
13	0	20	7	21	8	22	9	13	0	23	10	24	11	26	0
14	0	22	2	23	4	24	6	14	0	25	8	26	10	28	0
15	**0**	**23**	**9**	**25**	**0**	**26**	**3**	**15**	**0**	**27**	**6**	**28**	**9**	**30**	**0**
16	0	25	4	26	8	28	0	16	0	29	4	30	8	32	0
17	0	26	11	28	4	29	9	17	0	31	2	32	7	34	0
18	0	28	6	30	0	31	6	18	0	33	0	34	6	36	0
19	0	30	1	31	8	33	3	19	0	34	10	36	5	38	0
20	**0**	**31**	**8**	**33**	**4**	**35**	**0**	**20**	**0**	**36**	**8**	**38**	**4**	**40**	**0**
21	0	33	3	35	0	36	9	21	0	38	6	40	3	42	0
22	0	34	10	36	8	38	6	22	0	40	4	42	2	44	0
23	0	36	5	38	4	40	3	23	0	42	2	44	1	46	0
24	0	38	0	40	0	42	0	24	0	44	0	46	0	48	0
25	**0**	**39**	**7**	**41**	**8**	**43**	**9**	**25**	**0**	**45**	**10**	**47**	**11**	**50**	**0**
26	0	41	2	43	4	45	6	26	0	47	8	49	10	52	0
27	0	42	9	45	0	47	3	27	0	49	6	51	9	54	0
28	0	44	4	46	8	49	0	28	0	51	4	53	8	56	0
29	0	45	11	48	4	50	9	29	0	53	2	55	7	58	0
30	**0**	**47**	**6**	**50**	**0**	**52**	**6**	**30**	**0**	**55**	**0**	**57**	**6**	**60**	**0**

Lengths		2ft. 2in. wide.		2ft. 4in. wide.		2ft. 6in. wide.		Lengths.		2ft. 8in. wide.		2ft. 10in. wide.		3ft. 0in. wide.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
0	1	0	2	0	2	0	2	0	1	0	2	0	2	0	3
0	2	0	4	0	4	0	5	0	2	0	5	0	5	0	6
0	3	0	6	0	7	0	7	0	3	0	8	0	8	0	9
0	4	0	8	0	9	0	10	0	4	0	10	0	11	1	0
0	5	0	10	0	11	1	0	0	5	1	1	1	2	1	3
0	**6**	**1**	**1**	**1**	**2**	**1**	**3**	**0**	**6**	**1**	**4**	**1**	**5**	**1**	**6**
0	7	1	3	1	4	1	5	0	7	1	6	1	7	1	9
0	8	1	5	1	6	1	8	0	8	1	9	1	10	2	0
0	9	1	7	1	9	1	10	0	9	2	0	2	1	2	3
0	10	1	9	1	11	2	1	0	10	2	2	2	4	2	6
0	**11**	**1**	**11**	**2**	**1**	**2**	**3**	**0**	**11**	**2**	**5**	**2**	**7**	**2**	**9**
1	0	2	2	2	4	2	6	1	0	2	8	2	10	3	0
2	0	4	4	4	8	5	0	2	0	5	4	5	8	6	0
3	0	6	6	7	0	7	6	3	0	8	0	8	6	9	0
4	0	8	8	9	4	10	0	4	0	10	8	11	4	12	0
5	**0**	**10**	**10**	**11**	**8**	**12**	**6**	**5**	**0**	**13**	**4**	**14**	**2**	**15**	**0**
6	0	13	0	14	0	15	0	6	0	16	0	17	0	18	0
7	0	15	2	16	4	17	6	7	0	18	8	19	10	21	0
8	0	17	4	18	8	20	0	8	0	21	4	22	8	24	0
9	0	19	6	21	0	22	6	9	0	24	0	25	6	27	0
10	**0**	**21**	**8**	**23**	**4**	**25**	**0**	**10**	**0**	**26**	**8**	**28**	**4**	**30**	**0**
11	0	23	10	25	8	27	6	11	0	29	4	31	2	33	0
12	0	26	0	28	0	30	0	12	0	32	0	34	0	36	0
13	0	28	2	30	4	32	6	13	0	34	8	36	10	39	0
14	0	30	4	32	8	35	0	14	0	37	4	39	8	42	0
15	**0**	**32**	**6**	**35**	**0**	**37**	**6**	**15**	**0**	**40**	**0**	**42**	**6**	**45**	**0**
16	0	34	8	37	4	40	0	16	0	42	8	45	4	48	0
17	0	36	10	39	8	42	6	17	0	45	4	48	2	51	0
18	0	39	0	42	0	45	0	18	0	48	0	51	0	54	0
19	0	41	2	44	4	47	6	19	0	50	8	53	10	57	0
20	**0**	**43**	**4**	**46**	**8**	**50**	**0**	**20**	**0**	**53**	**4**	**56**	**8**	**60**	**0**
21	0	45	6	49	0	52	6	21	0	56	0	59	6	63	0
22	0	47	8	51	4	55	0	22	0	58	8	62	4	66	0
23	0	49	10	53	8	57	6	23	0	61	4	65	2	69	0
24	0	52	0	56	0	60	0	24	0	64	0	68	0	72	0
25	**0**	**54**	**2**	**58**	**4**	**62**	**6**	**25**	**0**	**66**	**8**	**70**	**10**	**75**	**0**
26	0	56	4	60	8	65	0	26	0	69	4	73	8	78	0
27	0	58	6	63	0	67	6	27	0	72	0	76	6	81	0
28	0	60	8	65	4	70	0	28	0	74	8	79	4	84	0
29	0	62	10	67	8	72	6	29	0	77	4	82	2	87	0
30	**0**	**65**	**0**	**70**	**0**	**75**	**0**	**30**	**0**	**80**	**0**	**85**	**0**	**90**	**0**

Lengths.		3ft. 2in. wide.		3ft. 4in. wide.		3ft. 6in. wide.		Lengths.		3ft. 8in. wide.		3ft. 10in. wide.		4ft. 0in. wide.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
0	1	0	3	0	3	0	3	0	1	0	3	0	3	0	4
0	2	0	6	0	6	0	7	0	2	0	7	0	7	0	8
0	3	0	9	0	10	0	10	0	3	0	11	0	11	1	0
0	4	1	0	1	1	1	2	0	4	1	2	1	3	1	4
0	5	1	3	1	4	1	5	0	5	1	6	1	7	1	8
0	**6**	**1**	**7**	**1**	**8**	**1**	**9**	**0**	**6**	**1**	**10**	**1**	**11**	**2**	**0**
0	7	1	10	1	11	2	0	0	7	2	1	2	2	2	4
0	8	2	1	2	2	2	4	0	8	2	5	2	6	2	8
0	9	2	4	2	6	2	7	0	9	2	9	2	10	3	0
0	10	2	7	2	9	2	11	0	10	3	0	3	2	3	4
0	**11**	**2**	**10**	**3**	**0**	**3**	**2**	**0**	**11**	**3**	**4**	**3**	**6**	**3**	**8**
1	0	3	2	3	4	3	6	1	0	3	8	3	10	4	0
2	0	6	4	6	8	7	0	2	0	7	4	7	8	8	0
3	0	9	6	10	0	10	6	3	0	11	0	11	6	12	0
4	0	12	8	13	4	14	0	4	0	14	8	15	4	16	0
5	**0**	**15**	**10**	**16**	**8**	**17**	**6**	**5**	**0**	**18**	**4**	**19**	**2**	**20**	**0**
6	0	19	0	20	0	21	0	6	0	22	0	23	0	24	0
7	0	22	2	23	4	24	6	7	0	25	8	26	10	28	0
8	0	25	4	26	8	28	0	8	0	29	4	30	8	32	0
9	0	28	6	30	0	31	6	9	0	33	0	34	6	36	0
10	**0**	**31**	**8**	**33**	**4**	**35**	**0**	**10**	**0**	**36**	**8**	**38**	**4**	**40**	**0**
11	0	34	10	36	8	38	6	11	0	40	4	42	2	44	0
12	0	38	0	40	0	42	0	12	0	44	0	46	0	48	0
13	0	41	2	43	4	45	6	13	0	47	8	49	10	52	0
14	0	44	4	46	8	49	0	14	0	51	4	53	8	56	0
15	**0**	**47**	**6**	**50**	**0**	**52**	**6**	**15**	**0**	**55**	**0**	**57**	**6**	**60**	**0**
16	0	50	8	53	4	56	0	16	0	58	8	61	4	64	0
17	0	53	10	56	8	59	6	17	0	62	4	65	2	68	0
18	0	57	0	60	0	63	0	18	0	66	0	69	0	72	0
19	0	60	2	63	4	66	6	19	0	69	8	72	10	76	0
20	**0**	**63**	**4**	**66**	**8**	**70**	**0**	**20**	**0**	**73**	**4**	**76**	**8**	**80**	**0**
21	0	66	6	70	0	73	6	21	0	77	0	80	6	84	0
22	0	69	8	73	4	77	0	22	0	80	8	84	4	88	0
23	0	72	10	76	8	80	6	23	0	84	4	88	2	92	0
24	0	76	0	80	0	84	0	24	0	88	0	92	0	96	0
25	**0**	**79**	**2**	**83**	**4**	**87**	**6**	**25**	**0**	**91**	**8**	**95**	**10**	**100**	**0**
26	0	82	4	86	8	91	0	26	0	95	4	99	8	104	0
27	0	85	6	90	0	94	6	27	0	99	0	103	6	108	0
28	0	88	8	93	4	98	0	28	0	102	8	107	4	112	0
29	0	91	10	96	8	101	6	29	0	106	4	111	2	116	0
30	**0**	**95**	**0**	**100**	**0**	**105**	**0**	**30**	**0**	**110**	**0**	**115**	**0**	**120**	**0**

Lengths.		4ft. 2in. wide.		4ft. 4in. wide.		4ft. 6in. wide.		Lengths.		4ft. 8in. wide.		4ft. 10in. wide.		5ft. 0in. wide.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
0	1	0	4	0	4	0	4	0	1	0	4	0	4	0	5
0	2	0	8	0	8	0	9	0	2	0	9	0	9	0	10
0	3	1	0	1	1	1	1	0	3	1	2	1	2	1	3
0	4	1	4	1	5	1	6	0	4	1	6	1	7	1	8
0	5	1	8	1	9	1	10	0	5	1	11	2	0	2	1
0	**6**	**2**	**1**	**2**	**2**	**2**	**3**	**0**	**6**	**2**	**4**	**2**	**5**	**2**	**6**
0	7	2	5	2	6	2	7	0	7	2	8	2	9	2	11
0	8	2	9	2	10	3	0	0	8	3	1	3	2	3	4
0	9	3	1	3	3	3	4	0	9	3	6	3	7	3	9
0	10	3	5	3	7	3	9	0	10	3	10	4	0	4	2
0	**11**	**3**	**9**	**3**	**11**	**4**	**1**	**0**	**11**	**4**	**3**	**4**	**5**	**4**	**7**
1	0	4	2	4	4	4	6	1	0	4	8	4	10	5	0
2	0	8	4	8	8	9	0	2	0	9	4	9	8	10	0
3	0	12	6	13	0	13	6	3	0	14	0	14	6	15	0
4	0	16	8	17	4	18	0	4	0	18	8	19	4	20	0
5	**0**	**20**	**10**	**21**	**8**	**22**	**6**	**5**	**0**	**23**	**4**	**24**	**2**	**25**	**0**
6	0	25	0	26	0	27	0	6	0	28	0	29	0	30	0
7	0	29	2	30	4	31	6	7	0	32	8	33	10	35	0
8	0	33	4	34	8	36	0	8	0	37	4	38	8	40	0
9	0	37	6	39	0	40	6	9	0	42	0	43	6	45	0
10	**0**	**41**	**8**	**43**	**4**	**45**	**0**	**10**	**0**	**46**	**8**	**48**	**4**	**50**	**0**
11	0	45	10	47	8	49	6	11	0	51	4	53	2	55	0
12	0	50	0	52	0	54	0	12	0	56	0	58	0	60	0
13	0	54	2	56	4	58	6	13	0	60	8	62	10	65	0
14	0	58	4	60	8	63	0	14	0	65	4	67	8	70	0
15	**0**	**62**	**6**	**65**	**0**	**67**	**6**	**15**	**0**	**70**	**0**	**72**	**6**	**75**	**0**
16	0	66	8	69	4	72	0	16	0	74	8	77	4	80	0
17	0	70	10	73	8	76	6	17	0	79	4	82	2	85	0
18	0	75	0	78	0	81	0	18	0	84	0	87	0	90	0
19	0	79	2	82	4	85	6	19	0	88	8	91	10	95	0
20	**0**	**83**	**4**	**86**	**8**	**90**	**0**	**20**	**0**	**93**	**4**	**96**	**8**	**100**	**0**
21	0	87	6	91	0	94	6	21	0	98	0	101	6	105	0
22	0	91	8	95	4	99	0	22	0	102	8	106	4	110	0
23	0	95	10	99	8	103	6	23	0	107	4	111	2	115	0
24	0	100	0	104	0	108	0	24	0	112	0	116	0	120	0
25	**0**	**104**	**2**	**108**	**4**	**112**	**6**	**25**	**0**	**116**	**8**	**120**	**10**	**125**	**0**
26	0	108	4	112	8	117	0	26	0	121	4	125	8	130	0
27	0	112	6	117	0	121	6	27	0	126	0	130	6	135	0
28	0	116	8	121	4	126	0	28	0	130	8	135	4	140	0
29	0	120	10	125	8	130	6	29	0	135	4	140	2	145	0
30	**0**	**125**	**0**	**130**	**0**	**135**	**0**	**30**	**0**	**140**	**0**	**145**	**0**	**150**	**0**

Lengths.		5ft. 2in. wide.		5ft. 4in. wide.		5ft. 6in. wide.		Lengths.		5ft. 8in. wide.		5ft. 10in. wide.		6ft. 0in. wide.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
0	1	0	5	0	5	0	5	0	1	0	5	0	5	0	6
0	2	0	10	0	10	0	11	0	2	0	11	0	11	1	0
0	3	1	3	1	4	1	4	0	3	1	5	1	5	1	6
0	4	1	8	1	9	1	10	0	4	1	10	1	11	2	0
0	5	2	1	2	2	2	3	0	5	2	4	2	5	2	6
0	**6**	**2**	**7**	**2**	**8**	**2**	**9**	**0**	**6**	**2**	**10**	**2**	**11**	**3**	**0**
0	7	3	0	3	1	3	2	0	7	3	3	3	4	3	6
0	8	3	5	3	6	3	8	0	8	3	9	3	10	4	0
0	9	3	10	4	0	4	1	0	9	4	3	4	4	4	6
0	10	4	3	4	5	4	7	0	10	4	8	4	10	5	0
0	**11**	**4**	**8**	**4**	**10**	**5**	**0**	**0**	**11**	**5**	**2**	**5**	**4**	**5**	**6**
1	0	5	2	5	4	5	6	1	0	5	8	5	10	6	0
2	0	10	4	10	8	11	0	2	0	11	4	11	8	12	0
3	0	15	6	16	0	16	6	3	0	17	0	17	6	18	0
4	0	20	8	21	4	22	0	4	0	22	8	23	4	24	0
5	**0**	**25**	**10**	**26**	**8**	**27**	**6**	**5**	**0**	**28**	**4**	**29**	**2**	**30**	**0**
6	0	31	0	32	0	33	0	6	0	34	0	35	0	36	0
7	0	36	2	37	4	38	6	7	0	39	8	40	10	42	0
8	0	41	4	42	8	44	0	8	0	45	4	46	8	48	0
9	0	46	6	48	0	49	6	9	0	51	0	52	6	54	0
10	**0**	**51**	**8**	**53**	**4**	**55**	**0**	**10**	**0**	**56**	**8**	**58**	**4**	**60**	**0**
11	0	56	10	58	8	60	6	11	0	62	4	64	2	66	0
12	0	62	0	64	0	66	0	12	0	68	0	70	0	72	0
13	0	67	2	69	4	71	6	13	0	73	8	75	10	78	0
14	0	72	4	74	8	77	0	14	0	79	4	81	8	84	0
15	**0**	**77**	**6**	**80**	**0**	**82**	**6**	**15**	**0**	**85**	**0**	**87**	**6**	**90**	**0**
16	0	82	8	85	4	88	0	16	0	90	8	93	4	96	0
17	0	87	10	90	8	93	6	17	0	96	4	99	2	102	0
18	0	93	0	96	0	99	0	18	0	102	0	105	0	108	0
19	0	98	2	101	4	104	6	19	0	107	8	110	10	114	0
20	**0**	**103**	**4**	**106**	**8**	**110**	**0**	**20**	**0**	**113**	**4**	**116**	**8**	**120**	**0**
21	0	108	6	112	0	115	6	21	0	119	0	122	6	126	0
22	0	113	8	117	4	121	0	22	0	124	8	128	4	132	0
23	0	118	10	122	8	126	6	23	0	130	4	134	2	138	0
24	0	124	0	128	0	132	0	24	0	136	0	140	0	144	0
25	**0**	**129**	**2**	**133**	**4**	**137**	**6**	**25**	**0**	**141**	**8**	**145**	**10**	**150**	**0**
26	0	134	4	138	8	143	0	26	0	147	4	151	8	156	0
27	0	139	6	144	0	148	6	27	0	153	0	157	6	162	0
28	0	144	8	149	4	154	0	28	0	158	8	163	4	168	0
29	0	149	10	154	8	159	6	29	0	164	4	169	2	174	0
30	**0**	**155**	**0**	**160**	**0**	**165**	**0**	**30**	**0**	**170**	**0**	**175**	**0**	**180**	**0**

Lengths.		6ft. 2in. wide.		6ft. 4in. wide.		6ft. 6in. wide.		Lengths.		6ft. 8in. wide.		6ft. 10in. wide.		7ft. 0in. wide.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
0	1	0	6	0	6	0	6	0	1	0	6	0	6	0	7
0	2	1	0	1	0	1	1	0	2	1	1	1	1	1	2
0	3	1	6	1	7	1	7	0	3	1	8	1	8	1	9
0	4	2	0	2	1	2	2	0	4	2	2	2	3	2	4
0	5	2	6	2	7	2	8	0	5	2	9	2	10	2	11
0	**6**	**3**	**1**	**3**	**2**	**3**	**3**	**0**	**6**	**3**	**4**	**3**	**5**	**3**	**6**
0	7	3	7	3	8	3	9	0	7	3	10	3	11	4	1
0	8	4	1	4	2	4	4	0	8	4	5	4	6	4	8
0	9	4	7	4	9	4	10	0	9	5	0	5	1	5	3
0	10	5	1	5	3	5	5	0	10	5	6	5	8	5	10
0	**11**	**5**	**7**	**5**	**9**	**5**	**11**	**0**	**11**	**6**	**1**	**6**	**3**	**6**	**5**
1	0	6	2	6	4	6	6	1	0	6	8	6	10	7	0
2	0	12	4	12	8	13	0	2	0	13	4	13	8	14	0
3	0	18	6	19	0	19	6	3	0	20	0	20	6	21	0
4	0	24	8	25	4	26	0	4	0	26	8	27	4	28	0
5	**0**	**30**	**10**	**31**	**8**	**32**	**6**	**5**	**0**	**33**	**4**	**34**	**2**	**35**	**0**
6	0	37	0	38	0	39	0	6	0	40	0	41	0	42	0
7	0	43	2	44	4	45	6	7	0	46	8	47	10	49	0
8	0	49	4	50	8	52	0	8	0	53	4	54	8	56	0
9	0	55	6	57	0	58	6	9	0	60	0	61	6	63	0
10	**0**	**61**	**8**	**63**	**4**	**65**	**0**	**10**	**0**	**66**	**8**	**68**	**4**	**70**	**0**
11	0	67	10	69	8	71	6	11	0	73	4	75	2	77	0
12	0	74	0	76	0	78	0	12	0	80	0	82	0	84	0
13	0	80	2	82	4	84	6	13	0	86	8	88	10	91	0
14	0	86	4	88	8	91	0	14	0	93	4	95	8	98	0
15	**0**	**92**	**6**	**95**	**0**	**97**	**6**	**15**	**0**	**100**	**0**	**102**	**6**	**105**	**0**
16	0	98	8	101	4	104	0	16	0	106	8	109	4	112	0
17	0	104	10	107	8	110	6	17	0	113	4	116	2	119	0
18	0	111	0	114	0	117	0	18	0	120	0	123	0	126	0
19	0	117	2	120	4	123	6	19	0	126	8	129	10	133	0
20	**0**	**123**	**4**	**126**	**8**	**130**	**0**	**20**	**0**	**133**	**4**	**136**	**8**	**140**	**0**
21	0	129	6	133	0	136	6	21	0	140	0	143	6	147	0
22	0	135	8	139	4	143	0	22	0	146	8	150	4	154	0
23	0	141	10	145	8	149	6	23	0	153	4	157	2	161	0
24	0	148	0	152	0	156	0	24	0	160	0	164	0	168	0
25	**0**	**154**	**2**	**158**	**4**	**162**	**6**	**25**	**0**	**166**	**8**	**170**	**10**	**175**	**0**
26	0	160	4	164	8	169	0	26	0	173	4	177	8	182	0
27	0	166	6	171	0	175	6	27	0	180	0	184	6	189	0
28	0	172	8	177	4	182	0	28	0	186	8	191	4	196	0
29	0	178	10	183	8	188	6	29	0	193	4	198	2	203	0
30	**0**	**185**	**0**	**190**	**0**	**195**	**0**	**30**	**0**	**200**	**0**	**205**	**0**	**210**	**0**

Lengths		7ft. 2in. wide.		7ft. 4in. wide.		7ft. 6in. wide.		Lengths.		7ft. 8in. wide.		7ft. 10in. wide.		8ft. 0in. wide.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
0	1	0	7	0	7	0	7	0	1	0	7	0	7	0	8
0	2	1	2	1	2	1	3	0	2	1	3	1	3	1	4
0	3	1	9	1	10	1	10	0	3	1	11	1	11	2	0
0	4	2	4	2	5	2	6	0	4	2	6	2	7	2	8
0	5	2	11	3	0	3	1	0	5	3	2	3	3	3	4
0	**6**	**3**	**7**	**3**	**8**	**3**	**9**	**0**	**6**	**3**	**10**	**3**	**11**	**4**	**0**
0	7	4	2	4	3	4	4	0	7	4	5	4	6	4	8
0	8	4	9	4	10	5	0	0	8	5	1	5	2	5	4
0	9	5	4	5	6	5	7	0	9	5	9	5	10	6	0
0	10	5	11	6	1	6	3	0	10	6	4	6	6	6	8
0	**11**	**6**	**6**	**6**	**8**	**6**	**10**	**0**	**11**	**7**	**0**	**7**	**2**	**7**	**4**
1	0	7	2	7	4	7	6	1	0	7	8	7	10	8	0
2	0	14	4	14	8	15	0	2	0	15	4	15	8	16	0
3	0	21	6	22	0	22	6	3	0	23	0	23	6	24	0
4	0	28	8	29	4	30	0	4	0	30	8	31	4	32	0
5	**0**	**35**	**10**	**36**	**8**	**37**	**6**	**5**	**0**	**38**	**4**	**39**	**2**	**40**	**0**
6	0	43	0	44	0	45	0	6	0	46	0	47	0	48	0
7	0	50	2	51	4	52	6	7	0	53	8	54	10	56	0
8	0	57	4	58	8	60	0	8	0	61	4	62	8	64	0
9	0	64	6	66	0	67	6	9	0	69	0	70	6	72	0
10	**0**	**71**	**8**	**73**	**4**	**75**	**0**	**10**	**0**	**76**	**8**	**78**	**4**	**80**	**0**
11	0	78	10	80	8	82	6	11	0	84	4	86	2	88	0
12	0	86	0	88	0	90	0	12	0	92	0	94	0	96	0
13	0	93	2	95	4	97	6	13	0	99	8	101	10	104	0
14	0	100	4	102	8	105	0	14	0	107	4	109	8	112	0
15	**0**	**107**	**6**	**110**	**0**	**112**	**6**	**15**	**0**	**115**	**0**	**117**	**6**	**120**	**0**
16	0	114	8	117	4	120	0	16	0	122	8	125	4	128	0
17	0	121	10	124	8	127	6	17	0	130	4	133	2	136	0
18	0	129	0	132	0	135	0	18	0	138	0	141	0	144	0
19	0	136	2	139	4	142	6	19	0	145	8	148	10	152	0
20	**0**	**143**	**4**	**146**	**8**	**150**	**0**	**20**	**0**	**153**	**4**	**156**	**8**	**160**	**0**
21	0	150	6	154	0	157	6	21	0	161	0	164	6	168	0
22	0	157	8	161	4	165	0	22	0	168	8	172	4	176	0
23	0	164	10	168	8	172	6	23	0	176	4	180	2	184	0
24	0	172	0	176	0	180	0	24	0	184	0	188	0	192	0
25	**0**	**179**	**2**	**183**	**4**	**187**	**6**	**25**	**0**	**191**	**8**	**195**	**10**	**200**	**0**
26	0	186	4	190	8	195	0	26	0	199	4	203	8	208	0
27	0	193	6	198	0	202	6	27	0	207	0	211	6	216	0
28	0	200	8	205	4	210	0	28	0	214	8	219	4	224	0
29	0	207	10	212	8	217	6	29	0	222	4	227	2	232	0
30	**0**	**215**	**0**	**220**	**0**	**225**	**0**	**30**	**0**	**230**	**0**	**235**	**0**	**240**	**0**

Lengths.		8ft. 2in. wide.		8ft. 4in. wide.		8 ft. 6in. wide.		Lengths.		8ft. 8in. wide.		8ft. 10in. wide.		9ft. 0in. wide.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
0	1	0	8	0	8	0	8	0	1	0	8	0	8	0	9
0	2	1	4	1	4	1	5	0	2	1	5	1	5	1	6
0	3	2	0	2	1	2	1	0	3	2	2	2	2	2	3
0	4	2	8	2	9	2	10	0	4	2	10	2	11	3	0
0	5	3	4	3	5	3	6	0	5	3	7	3	8	3	9
0	**6**	**4**	**1**	**4**	**2**	**4**	**3**	**0**	**6**	**4**	**4**	**4**	**5**	**4**	**6**
0	7	4	9	4	10	4	11	0	7	5	0	5	1	5	3
0	8	5	5	5	6	5	8	0	8	5	9	5	10	6	0
0	9	6	1	6	3	6	4	0	9	6	6	6	7	6	9
0	10	6	9	6	11	7	1	0	10	7	2	7	4	7	6
0	**11**	**7**	**5**	**7**	**7**	**7**	**9**	**0**	**11**	**7**	**11**	**8**	**1**	**8**	**3**
1	0	8	2	8	4	8	6	1	0	8	8	8	10	9	0
2	0	16	4	16	8	17	0	2	0	17	4	17	8	18	0
3	0	24	6	25	0	25	6	3	0	26	0	26	6	27	0
4	0	32	8	33	4	34	0	4	0	34	8	35	4	36	0
5	**0**	**40**	**10**	**41**	**8**	**42**	**6**	**5**	**0**	**43**	**4**	**44**	**2**	**45**	**0**
6	0	49	0	50	0	51	0	6	0	52	0	53	0	54	0
7	0	57	2	58	4	59	6	7	0	60	8	61	10	63	0
8	0	65	4	66	8	68	0	8	0	69	4	70	8	72	0
9	0	73	6	75	0	76	6	9	0	78	0	79	6	81	0
10	**0**	**81**	**8**	**83**	**4**	**85**	**0**	**10**	**0**	**86**	**8**	**88**	**4**	**90**	**0**
11	0	89	10	91	8	93	6	11	0	95	4	97	2	99	0
12	0	98	0	100	0	102	0	12	0	104	0	106	0	108	0
13	0	106	2	108	4	110	6	13	0	112	8	114	10	117	0
14	0	114	4	116	8	119	0	14	0	121	4	123	8	126	0
15	**0**	**122**	**6**	**125**	**0**	**127**	**6**	**15**	**0**	**130**	**0**	**132**	**6**	**135**	**0**
16	0	130	8	133	4	136	0	16	0	138	8	141	4	144	0
17	0	138	10	141	8	144	6	17	0	147	4	150	2	153	0
18	0	147	0	150	0	153	0	18	0	156	0	159	0	162	0
19	0	155	2	158	4	161	6	19	0	164	8	167	10	171	0
20	**0**	**163**	**4**	**166**	**8**	**170**	**0**	**20**	**0**	**173**	**4**	**176**	**8**	**180**	**0**
21	0	171	6	175	0	178	6	21	0	182	0	185	6	189	0
22	0	179	8	183	4	187	0	22	0	190	8	194	4	198	0
23	0	187	10	191	8	195	6	23	0	199	4	203	2	207	0
24	0	196	0	200	0	204	0	24	0	208	0	212	0	216	0
25	**0**	**204**	**2**	**208**	**4**	**212**	**6**	**25**	**0**	**216**	**8**	**220**	**10**	**225**	**0**
26	0	212	4	216	8	221	0	26	0	225	4	229	8	234	0
27	0	220	6	225	0	229	6	27	0	234	0	238	6	243	0
28	0	228	8	233	4	238	0	28	0	242	8	247	4	252	0
29	0	236	10	241	8	246	6	29	0	251	4	256	2	261	0
30	**0**	**245**	**0**	**250**	**0**	**255**	**0**	**30**	**0**	**260**	**0**	**265**	**0**	**270**	**0**

Lengths.		9ft. 2in. wide.		9ft. 4in. wide.		9ft. 6in. wide.		Lengths.		9ft. 8in. wide.		9ft. 10in. wide.		10ft. 0in. wide.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
0	1	0	9	0	9	0	9	0	1	0	9	0	9	0	10
0	2	1	6	1	6	1	7	0	2	1	7	1	7	1	8
0	3	2	3	2	4	2	4	0	3	2	5	2	5	2	6
0	4	3	0	3	1	3	2	0	4	3	2	3	3	3	4
0	5	3	9	3	10	3	11	0	5	4	0	4	1	4	2
0	**6**	**4**	**7**	**4**	**8**	**4**	**9**	**0**	**6**	**4**	**10**	**4**	**11**	**5**	**0**
0	7	5	4	5	5	5	6	0	7	5	7	5	8	5	10
0	8	6	1	6	2	6	4	0	8	6	5	6	6	6	8
0	9	6	10	7	0	7	1	0	9	7	3	7	4	7	6
0	10	7	7	7	9	7	11	0	10	8	0	8	2	8	4
0	**11**	**8**	**4**	**8**	**6**	**8**	**8**	**0**	**11**	**8**	**10**	**9**	**0**	**9**	**2**
1	0	9	2	9	4	9	6	1	0	9	8	9	10	10	0
2	0	18	4	18	8	19	0	2	0	19	4	19	8	20	0
3	0	27	6	28	0	28	6	3	0	29	0	29	6	30	0
4	0	36	8	37	4	38	0	4	0	38	8	39	4	40	0
5	**0**	**45**	**10**	**46**	**8**	**47**	**6**	**5**	**0**	**48**	**4**	**49**	**2**	**50**	**0**
6	0	55	0	56	0	57	0	6	0	58	0	59	0	60	0
7	0	64	2	65	4	66	6	7	0	67	8	68	10	70	0
8	0	73	4	74	8	76	0	8	0	77	4	78	8	80	0
9	0	82	6	84	0	85	6	9	0	87	0	88	6	90	0
10	**0**	**91**	**8**	**93**	**4**	**95**	**0**	**10**	**0**	**96**	**8**	**98**	**4**	**100**	**0**
11	0	100	10	102	8	104	6	11	0	106	4	108	2	110	0
12	0	110	0	112	0	114	0	12	0	116	0	118	0	120	0
13	0	119	2	121	4	123	6	13	0	125	8	127	10	130	0
14	0	128	4	130	8	133	0	14	0	135	4	137	8	140	0
15	**0**	**137**	**6**	**140**	**0**	**142**	**6**	**15**	**0**	**145**	**0**	**147**	**6**	**150**	**0**
16	0	146	8	149	4	152	0	16	0	154	8	157	4	160	0
17	0	155	10	158	8	161	6	17	0	164	4	167	2	170	0
18	0	165	0	168	0	171	0	18	0	174	0	177	0	180	0
19	0	174	2	177	4	180	6	19	0	183	8	186	10	190	0
20	**0**	**183**	**4**	**186**	**8**	**190**	**0**	**20**	**0**	**193**	**4**	**196**	**8**	**200**	**0**
21	0	192	6	196	0	199	6	21	0	203	0	206	6	210	0
22	0	201	8	205	4	209	0	22	0	212	8	216	4	220	0
23	0	210	10	214	8	218	6	23	0	222	4	226	2	230	0
24	0	220	0	224	0	228	0	24	0	232	0	236	0	240	0
25	**0**	**229**	**2**	**233**	**4**	**237**	**6**	**25**	**0**	**241**	**8**	**245**	**10**	**250**	**0**
26	0	238	4	242	8	247	0	26	0	251	4	255	8	260	0
27	0	247	6	252	0	256	6	27	0	261	0	265	6	270	0
28	0	256	8	261	4	266	0	28	0	270	8	275	4	280	0
29	0	265	10	270	8	275	6	29	0	280	4	285	2	290	0
30	**0**	**275**	**0**	**280**	**0**	**285**	**0**	**30**	**0**	**290**	**0**	**295**	**0**	**300**	**0**

CHAPTER XVI.

ARTIFICERS' WORK.

SECT. I.—*Bricklayer and Excavator's Work.*

THE standard measure for Brickwork in London is the rod of 16 ft. 6 in. square, which dimension being multiplied into itself produces 272 ft. 3 in., but the odd 3 inches are never taken into account. It is therefore always considered as 272 superficial feet, at 1½ brick, or 13½ inches thick, or 306 feet cube, viz., 272 ft. by 1 ft. 1½ in. All the other thicknesses are reduced to this standard, as shown hereafter in the manner of taking the dimensions and abstracting the work.

In measuring bricklayers' work, it is usual to begin by taking the excavations; first, for the basement story, if any, which is stated as digging and throwing out or wheeling away; the ground for sunk stories, according to circumstances; next the excavations for footings to walls.

It is customary in taking the digging to footings of walls, to allow about six inches on each side, over and above the thickness of the walls, for room to work them; but if they are deep, and the ground bad and loose, allow nine inches on each side on account of its falling in. But in sunk stories only allow to the extent of the footings, except in very loose ground.

In taking the dimensions, the length, depth, and width must be measured as before described, and reduced to the yard cube of 27 feet, viz., 3 ft. by 3 ft. by 3 ft.

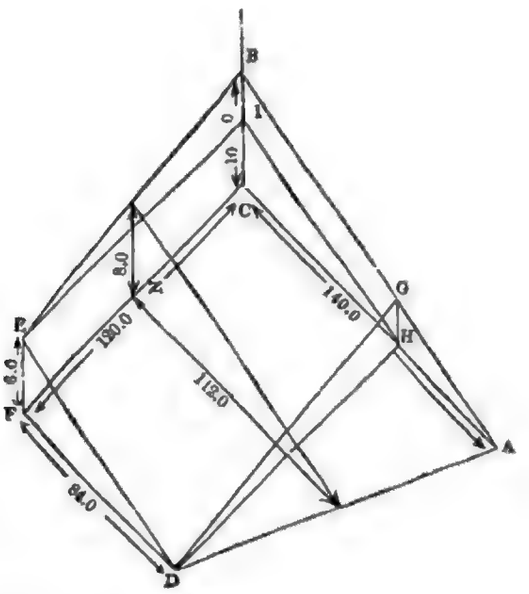
Claying of Vaults, by the yard square of 9 feet, describing the thickness, 3 ft. by 3 ft.

In measuring digging in sideling ground, where the areas of the two ends of the excavation are unequal, the cubic content must be found by the following rule:—

Multiply the sum of the extreme areas, plus four times the middle area, by one-sixth of the length, and the product will be the answer required.

Ex.—To find the cubic content of the excavation A B C D E F

for the sunk stories of a house, to be built on the side of a hill :—



$$\frac{140 \times 10}{2} = 700$$

$$\frac{84 \times 6}{2} = 252$$

952 sum of extreme areas

$$\frac{112 \times 8}{2} = 1792$$ four times middle area

2744

120 length

54880

2744

6)329280

27) 54880 (2032 yards 16 feet

54

88

81

70

54

16

As an illustration of the correctness of the rule, let us take the same example on a different principle of measurement. The solid

A B C D E F may be divided into the two prisms G H I B E D, and E F C I H D and the pyramid D A H G. Taking each of these separately, we have—

$$\text{Prism G H I B E D} = \frac{84 \times 4 \times 120}{2} = 20160$$

$$\text{Prism E F C I H D} = \frac{120 \times 6 \times 84}{2} = 30240$$

$$\text{Pyramid D A H G} = \frac{56 \times 4}{2} \times \frac{120}{3} = 4480$$

Total . 54880 cubic ft.

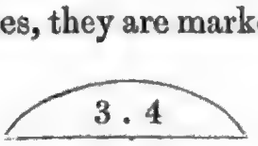
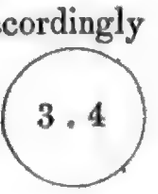
or 2032 yards 16 feet, as before.

In measuring brickwork, always begin with the foundations, then proceed with measuring each story separately (or as high as the wall continues of the same thickness), as solid work, according to its respective thickness; then add for all projections, as breasts of chimneys, &c., deducting the openings, but not the flues, as the extra trouble and the pargetting is deemed equivalent to the deficiency of materials; but deduct the openings of doors, windows, &c.

If the house or building be rectangular, measure two walls the whole length of the external face, and the other two internally, so as to get the true cubical contents.

But in measuring for labour only, the external face of the work is girt, and multiplied into the height and thickness, to pay for the extra labour of plumbing the angles, andworking the returns fair.

In measuring walls that are faced with superior bricks, the walls are first measured as common work, and then the superficial quantity of facing is taken, as hereafter shown, and is valued by considering the facing as two-thirds of a brick thick, and deducting the common brickwork from the price thereof, the same thickness, viz., two-thirds of a brick; by which the value per foot superficial is ascertained.

In measuring circles, or semicircles, they are marked accordingly in the measuring-book, thus:  or  with the diameters figured.

To measure angle chimneys, draw lines on the floor, parallel to the two sides of the room, cutting the parts intersected by the chimney; take either side by the height of the floor, and half the other (the work forming a triangle) for the thickness, either as the number of bricks, or as cube work, which, by the directions before

given, prove it to be exactly the same: consequently, if the projection should not amount to any certain number of half-bricks, it would be best to take it as a cube dimension. In all cases it is supposed that the walls are measured before the projecting chimneys are taken, which is the usual custom.

In taking the dimensions of vaults, measure the abutments, or side walls, to the springing of the arch, then bend your rods round the soffit of the arch; and add once and a half the thickness thereof, by which you obtain the average girt of the arch; then take the length clear of the walls; but if the arch is turned over one or both walls, add the thickness thereof to the length of the arch. But in taking the height of the walls, measure to the crown of the arch, without making any deduction for the declivity of the arches, on account of the additional trouble and waste of bricks, in cutting and fitting them to the curved soffit of the arch. Likewise, in deducting openings with circular heads, the dimensions should only be taken to the springing of the arches, on account of the trouble and waste of bricks in fitting them to the arches.

Drains to be taken and reduced as common brickwork if built with mortar.

Shafts of chimneys are measured as solid work.

Ovens and coppers are measured as solid cube brickwork, deducting the ash-holes only.* Tiles, Welsh lumps, and fire bricks are to be allowed as extras.

In these, or any other brickwork that it is considered best or most convenient to measure by the cubic foot, multiply the solidity by 8, the number of $1\frac{1}{2}$ inches in a foot, and divide it by 9, the number of $1\frac{1}{2}$ inches in $13\frac{1}{2}$ inches, which will reduce it to the standard of $1\frac{1}{2}$ brick or $13\frac{1}{2}$ inches in thickness.

In measuring brickwork no allowance is to be made in quantity for small or difficult works. Timbers inserted in the walls are not to be deducted. When plates are bedded in the walls, two inches to be allowed for ditto where no brickwork is over them. All sills and stone strings are measured in.

All cuttings to be measured superficial; as outside splays, cut and rubbed to show fair, or inside ditto rough cut for battens, &c.

Birds' mouths at per foot run, being notched to fit.

Facings of all descriptions to be measured extra by the foot superficial; in which case the reveals are also measured, except where intended to be stuccoed.

* This method is in common use amongst surveyors; but it would be far more consistent to measure the actual quantity of brickwork, allowing for the extra labour in price.

Gauged arches to doors, windows, &c., are also measured by the foot superficial.

Groins are measured as common work, only taking the run of cut groins at per foot.

Bricknogging, by the yard square of nine feet, including the timbers.

Brick paving, ditto, ditto.

Facias, beads, and quirks, dentil or plain cornices, &c., measured and valued by the foot run.

TILING.

Plane and pan tiling are measured by the square of 100 feet.

In measuring plane tiling—

Allow for the eaves 4 inches extra.
Ditto for dripping do. 6 inches extra.
Ditto for all cuttings, hips, &c., 3 inches extra.
Ditto for valleys, 12 inches extra.

In measuring pan tiling—

Allow for the barge per foot run.
Ditto for heading to barge per foot run.
Ditto for cutting to hips and splays per foot run.
Ditto for hips and ridges per foot run.

Number the hip hooks, which should be painted three times in oil.

Ditto T nails, ditto.

Deduct for chimneys, and deduct and add for dormers.

If the roofs are hipped, take the length at the bottom of the sides, and not measure the end; the two side triangles being equal to the hipped end one.

Valuation of Bricklayers' Work.

CALCULATION OF MATERIALS.

Digger.—27 cubic feet, or one cubic yard, is called a single load, and contains 21 striked bushels. Two cubic yards = one double load.

In estimating the cubic content of excavation required to form a given amount of embankment, due regard must be paid to the nature of the soil of which the embankment is to be formed.

The following may be safely taken as average rates of the alteration in bulk of various soils when excavated and carried into embankment.

Clays.—Compression about one-tenth of the original bulk in excavation.

Gravels.—Compression about one-twelfth of the original bulk in excavation.

Sand occupies the same space in bank as in excavation.

Chalk.—Slight increase of the original bulk in excavation, proportionate to the size and hardness of the fragments.

Rock.—Increase about one-half of the original bulk in excavation, according to the size of the fragments.

23½	cubic feet of	sand	weigh one ton.
21¾	do.	gravel	do.
17	do.	clay	do.
13	do.	chalk	do.
18	do.	night-soil	do.

Concrete is made of ground stone lime and sharp gravel, with a proper proportion of sand, mixed in the proportion of five or six parts of gravel to one of lime, according to the nature of the lime and the proportion of sand mixed with the gravel. Its quality is much improved by the addition of smith's ashes, or any material containing iron; and for this reason ferruginous gravel is to be preferred whenever it can be obtained.

A cubic yard of concrete, containing 27 cubic feet when mixed, requires 34 cubic feet of gravel, sand, and lime. Therefore, at the proportion of six of gravel to one of lime, a cubic yard of concrete will require 1.1 cubic yard of gravel and sand and three bushels of lime.

Concrete expands slightly in slaking; but this expansion is too trifling to be taken into account in framing an estimate.

Size and Weight of various Articles.

	Length.		Breadth.		Thickness.		Weight.	
	ft.	in.	ft.	in.	ft.	in.	lbs.	oz.
Stock bricks . . . each .	0	8¾	0	4¼	0	2½	5	0
Paving do. do. .	0	9	0	4½	0	1¾	4	0
Dutch Clinkers . . . do. .	0	6¼	0	3	0	1⅛	1	8
12-inch paving tiles . . do. .	0	11¾	0	11¾	0	1½	13	0
10-inch do. do. .	0	9¾	0	9¾	0	1	8	9
Pan tiles do. .	1	1½	0	9½	0	0½	5	4
Plain tiles do. .	0	10½	0	6½	0	0⅝	2	5
Pan tile laths, per 10 ft. bundle .	120	0	0	1¼	0	1	4	6
Ditto, per 12 ft. bundle . . .	144	0	0	1½	0	1	5	0
A bundle contains 12 laths.								
Plain tile laths, per bundle . .	500	0	0	1	0	0¼	3	0
Thirty bundles of laths make a load								

A bricklayer's hod measures 1 ft. 4 in. × 9 in × 9 in., and will hold 20 bricks.

A single load of sand is 27 cubic feet, or one cubic yard.

A double load of sand is 54 cubic feet, or two cubic yards.

A measure of lime is 27 cubic feet, or one cubic yard, and contains from 16 to 18 bushels.

QUANTITIES, ETC.

A rod of brickwork measures 16 ft. 6 in. × 16 ft. 6 in., or 272 ft. 3 in. superf., 1½ brick or 13½ inches thick, called the standard thickness, or 306 cubic feet, or 11⅓ cubic yards.

A rod of brickwork laid to a 12-inch gauge, *i.e.*, four courses to measure one foot in height requires 4353 stock bricks.

Ditto, laid to 11½-inch gauge, requires 4533 stock bricks.

A foot of reduced brickwork requires 16 bricks.

These calculations are made without allowance for waste; and indeed there is very little, as nearly every part is worked in, and much space is occupied by timbers, flues, &c., for which no deduction is made in measurement; and therefore in the erection of dwelling-houses containing flues and bond timbers, 4300 stocks is quite sufficient, and this is the usual number allowed for a rod of brickwork.

5370 stocks to the rod, if laid dry.

4900 do. in wells and circular cesspools.

A rod of brickwork, laid four courses to gauge 12 inches, contains 235 ft. cube of bricks, and 71 ft. cube of mortar; and the average weight is about 15 tons.

A rod of brickwork requires 1½ cubic yard of chalk lime and three loads of sand; or one cubic yard of stone lime, and 3½ loads of sand; or 36 bushels of cement, and 36 bushels of sharp sand.

A cubic yard or load of mortar requires nine bushels of lime and one load of sand.

The proportion of mortar or cement, when made up, to the materials in their mixed state, is as two to three.

Facing requires 7 bricks per foot superficial.

Gauged arches 10 do. do.

Bricknogging per yard superficial, requires 30 bricks on edge, or 45 laid flat.

PAVING.

Description.	Number required.
Stock bricks, laid flat . . per yard .	36
Do. . . on edge . „ . .	52

Description.		Number required.
Paving bricks, laid flat	per yard	36
Do.	on edge „	82
Dutch clinkers	„ „	140
12-inch paving tiles	„	9
10-inch do.	„	13

TILING.

	Gauge.	Number required.
	inches.	
Pan tiles, per square	12	150
Ditto ditto	11	164
Ditto ditto	10	180
A square of pan tiling requires one bundle of laths and 1¼ hundred of 6*d.* nails.		
Plain tiles, per square	4	600
Ditto ditto	3½	700
Ditto ditto	3	800
Ditto ditto	laid flat	210
A square of plain tiling requires one bundle of laths and nails, one peck of tile pins, and three hods of mortar.		

Calculation of Labour.

Digger.—The amount of digging which a man can perform in a day depends so much on the nature of the soil on which he has to operate, that it is almost impossible to fix a constant for this description of labour: the following data may, however, serve as a slight guide.

In loose ground a man will throw up about ten cubic yards per day; but in hard or gravelly soils, where *hacking* is necessary, from three to five cubic yards, according to the hardness of the ground, will be a fair day's work.

Wheeling is estimated by the run of 20 yards. A gang of three men, two for filling and one for wheeling, will remove about 30 yards per day to this distance; and the labour of removing earth may be calculated according to distance, allowing three men to the first run, and an additional man for every twenty yards of distance.

The following table, although far from complete, contains constants for all the principal descriptions of bricklayer's work.

	Constant. To be multiplied by the rate of wages for a labourer per day.
Concrete.—Labour in mixing, wheeling, throwing in from a stage, and puddling (where required to be done), including erection of scaffolding, per yard cube	.335
	To be multiplied by the rate of wages for a bricklayer and labourer per day.
Brickwork, per rod	4.941
	To be multiplied by the rate of wages for a bricklayer per day.
Extra labour to malm facings	.014
	To be multiplied by the rate of wages for a bricklayer and labourer per day.
Paving.	
Brick paving laid flat in sand . . per yard . .	.046
Do. laid on edge in sand . . „ . . .	.075
Do. laid flat in mortar . . . „ . . .	.056
Do. laid on edge in mortar . . „ . . .	.084
Paving-brick paving laid flat in sand . „ . . .	.046
Paving-brick paving laid on edge in sand, per yard	.106
Do. laid flat in mortar „ .	.075
Do. on edge in mortar „ .	.121
Clinker paving on edge in sand . . . „ .	.132
10 or 12 inch tile paving „ .	.010
Tiling.	
Pan tiling laid dry per square	.422
Do. pointed outside „ .	.685
Do. pointed inside and outside . . „ .	.790
Plain tiling laid to a 4-inch gauge . . „ .	.739
Do. . . to a 3½-inch gauge . „ .	.764
Do. . . to a 3-inch gauge . . „ .	.790

Sect. II.—*Slater's Work.*

Slating is measured superficially, and charged per square of 100 feet.

In measuring, allow for the eaves whatever the bottom course measures, and for the hips and valleys measure their length by 12 inches, viz., six inches on each side; also the length of all irregular angles, as chimneys, dormers, &c., by six inches wide, as a fair allowance for cutting and waste.

For circular slating allow one-third extra.

VALUATION OF SLATER'S WORK.

Table of Materials and Labour.

Average sizes of Slates.	Average gauge when laid.	1200 will cover squares.	Weight per thousand of 1200 in tons.	Number required to cover one square.	Nails required to a square.		Constant.	
					Iron, cast or wrought, at per hundred.	Copper, at per lb.	To be multiplied by the rate of wages for a slater per diem.	
	ft. in. ft. in.	in.				lbs.		
Doubles	1 1 by 0 6	$5\frac{1}{2}$	$2\frac{1}{2}$	$\frac{3}{4}$	480	480	5	.173
Ladies	1 3 „ 0 8	7	$4\frac{1}{2}$	$1\frac{1}{4}$	280	280	3	.155
Countesses	1 8 „ 0 10	10	$7\frac{1}{2}$	2	160	320	$3\frac{3}{4}$	.137
Duchesses	2 0 „ 1 0	11	10	3	127	254	$2\frac{3}{4}$	.119
Tavistock			$3\frac{1}{2}$					
			A ton will cover.					
Imperials	2 6 „ 2 0		$2\frac{1}{4}$ to $2\frac{1}{2}$					
Rags and Queens . .	3 0 „ 2 0							
Westmorelands, various			$2\frac{1}{4}$					

Example.—To find the value of a square of duchess slating copper nailed.

	£	s.	d.
No. 127. Duchesses, at per thousand . .			
2¾ lbs. of copper nails, at per lb. . . .			
—— per cent. profit			
Labour on above, at per day			
Value per square . .	£		

SECT. III.—*On Carpenters' and Joiners' Work.*

MEASURING.

There are two methods of measuring carpenters' work: one by taking the superficial contents of roofs, floors, partitions, &c., at per square of 100 feet for the labour and nails, and then the cube contents of the timber without labour; the other, by measuring the cube contents of the timber as cube fir and labour, framed, &c. &c.

If the scantlings of the timber are small or light, it will pay the carpenter best to measure the roofs, floors, &c. as labour and nails, and the timber as no labour; but if the scantlings of the timber are large and heavy, then it will be more to his advantage to measure the work as timber, with the particular labour thereon, as follows:—

If the work is measured as timber and labour, the scantling of each piece is taken as cube fir or oak and labour, and entered accordingly; as

Cube fir, or oak, in ground joists, bonds, lintels, plates, &c., labour and nails, included.

Do. framed in roofs, partitions, naked floors, &c., labour and nails included.

Do. . do. . . truss framed . . do.

Do. wrought and framed do.

Do. wrought, framed, and rebated do.

Do. wrought, framed, rebated, and beaded, labour and nails included.

Do. in door-cases.

Oak trusses put into girders, per foot run, stating their size, as 4 inch square, &c.

In measuring for labour and nails to roofs, naked framed floors, ceiling floors, quarter partitions, or any other rough framed work,

the dimensions should be taken from the exteme ends of the timber each way, to ascertain the superficial contents thereof, as labour and nails at per square of 100 superficial feet. The openings to chimneys, staircases, &c. are not to be deducted, as the trouble of framing the trimmers and the joists into those openings is fully equivalent to running the joists through them. The same rule must be observed in taking the labour and nails in quarter partitions, as doors, &c., which must be entered in the measuring-book and valued according to the description of the work, as follows :—

For Roofs.

Labour and nails to common shed roofing.
Do. . do. with purlins.
Do. . do. with purlins and struts.
Do. . do. common span or valley with purlins and rafters.
Do. . do. span with collars, dovetailed into sides of rafters notched to receive purlins, filled in with common rafters.
Do. . do. framed with principals, king posts, two struts and purlins, filled in with common rafters.
Do. . do. do. with king and queen posts.
Do. . do. common kerb roof.

For Floors.

Labour and nails to fir ground joists, bedded and not framed.
Do. . do. pinned down on plates and framed to chimneys.
Do. . do. single framed floors, trimmed to chimneys and stairs.
Do. . do. with girders and cased bays.
Do. . do. framed floors, with girders, binding, bridging, and ceiling joists.
Do. . do. to common framed ceiling floors, with binding and ceiling joists.

Quarter Partitions.

Labour and nails to common 4 in. quarter partitions.
Do. . do. . 5 in. do.
Do. . do. . 6 in. do.
Do. . do. truss framed with king posts.
Do. . do. . do. with king and queen posts.

If oak is used, describe it.

Having taken the labour and nails, you must then proceed to take the timber therein, which must be entered as cube fir, or oak without labour.

In roofs, it is customary to take the highest timbers first, as the ridge piece, hips, &c., next the rafters, and so proceed downwards to the ceiling floor.

In partitions, floors, &c., begin with the timbers of the largest scantlings. Wherever a tenon is made, the length must be taken from the ends of the tenon, and not from the shoulders. Likewise the length of joists, including the part in the wall.

In measuring king and queen posts, take the whole length by the scantling of the shoulders. The parallel pieces sawed out for the abutment of the principal rafters must be deducted, should they exceed 2 feet in length and 2½ inches in thickness; but taken 5 or 6 inches short of the length between the shoulders, as the saw cannot enter with much less waste. But if the pieces are less than 2½ inches thick, no deduction must be made, they not being worth more than the labour of cutting them out.

ROOFS.

Hips and valley to be taken at per foot run, for cutting and waste.

All plates, lintels, discharging pieces, to be taken as bond timber.

Gutter plates, diagonal ties, dragging pieces or braces, struts, and tie-beams, as fir framed.

Deduct half the length of bond timbers running through openings.

Allow the length of dovetails or scarf in bond timber, but only taken as bond timber.

Fixing iron straps, screw bolts, hanging ditto, and all iron-work, to be taken and allowed extra.

FLOORS.

Oak trusses, let into breastsummers, to be taken at per foot run.

Oak king or queen posts, let into brestsummers, each at ———.

Girders sawed down, reversed and bolted, per foot run extra.

Letting in screw-bolts, plates, &c., each extra.

Common or herring-bone strutting between the joists, per foot run extra.

Furrings to ceilings, quarter partitions, battenings to walls, &c., are measured by the square, including labour and nails, and valued according to the thickness of the deals, used from ¾ to 3 inches

thick. Describe the battening either as framed or nailed only, or if plugged, or if with horizontal backings.

All wall-hooks and holdfasts to be allowed extra.

Centring to groins, vaults, recesses, &c.—Take the depth by the circumference for the superficial dimensions, which is valued at per square for use and waste, materials and time. If taken in this way, the whole of the vaults or recesses must be taken, although the same centring might have been used. But where there are a number of vaults or recesses of the same size, the fairest way is to allow the whole of the materials and time, or if any trifling alteration only is wanted, to allow the time expended in doing it.

Bracketing to cornices, to be measured at per foot superf., according to the girt, viz., 24½ inches by the length, as whole or 1½ inch deal, according to the thickness of deals used. Some allow the bracketing the same girt as the cornice.

inches.
6
1½
9
6½
1½
24½

Cradling for entablatures, measured and charged per foot superf., according to their thickness.

All circular bracketing, cradlings, &c., to be charged double those of straight work.

Ashlering at per foot superf., according to the thickness of the deals used.

Gutters and bearers.—Measure the length, then the breadth of the bottom and half the eaves-board.

Gutters between the roofs having two eaves-boards, one on each side, take for the width of gutter one of them.

Arris or fillet gutters per foot superf.

Water trunks per foot run; describe size, and allow for laps and half the length of shoe.

Sound boarding.—Measure the dimensions between the joists at per foot superf.; observe if single or double fillets.

Chimney grounds, per foot superf.

If the side grounds are very narrow, framed only for small mouldings, take them by the foot run, and enter them as narrow framed grounds.

Hinges to be numbered and described.

Skirtings, either plain or raking, taken at per foot superf.

If on narrow grounds, take them per foot run.

If plugged to the walls, allow extra for plugging.

Moulded plinths.—Measure the square part by the length and width, and enter it. Whole deal, wrought one side, rebated and backed plinth. Girt the moulding, and allow half an inch behind the plinth.

Flooring.—In measuring boarded flooring, the dimensions must be taken, allowing the thickness of the skirting, and valued at per square.

Enter them according to their thickness, and if yellow or white deal, if common or second best or clean deal, if laid folding, straight joint or dowelled.

The slabs are not generally deducted if they have mitred borders; if they have not mitred borders, deduct the opening or slab from the flooring. If the deduction is made when there are borders, the borders must be taken at per foot run, which will amount to as much as the deduction made on the floor.

Moulding, such as architraves, round doors, windows, &c., base, surbase, &c., &c., are to be measured round the mitres and girt with a fine tape, and entered as moulded architrave, base, &c., as the case may be. But in the abstract, they must be all classed under the same head as mouldings.

Single mouldings, as Q^k O G and bead, or Q^k ovolo and bead, &c., may be taken at per foot run, but their girt must be described, as they will be valued accordingly.

Doorcases, linings, &c., &c.—Doors are measured and valued at per foot superficial, according to their description. Solid doorcases are taken at per foot cube.

Door linings, grounds, &c, at per foot superficial.

If there is a sill, take it the same as the head, viz., by making an allowance for its passing under and beyond the jambs, as may be; and also allow the additional length of jambs for framing into ditto. If a stone sill, iron shoes should be secured to the bottom of jambs, which must be numbered.

Sashes and frames, shutters, and fitting up to windows.—Take the dimensions from the beads of sashes on the inside, and allow seven inches additional height for head and sill, and eight inches in width for frames in common sashes; but nine inches for large sashes.

French sashes, hung on hinges, or sashes hung on centres in solid frames.—Take the sashes separate, and the frames as directed for doorcases. If Venetian frames, describe them as such.

If mouldings up munten, take them per foot run.

If circular heads, take the sash by itself, and the frames as run of circular frames, as per description, viz., with beads, parting slips, &c., &c., as may be.

Window shutters are taken per foot superficial, allowing for the rebates.

Number the sash fastenings, locking bars, spring latches, hinges, &c., &c.

The framed grounds, rebated and beaded boxings, linings, moulded architraves, &c., are taken per foot superficial, similar to the doors.

Staircases are taken per foot superficial, by girting the riser and tread by the length of the step, allowing extra for the thickness of the skirting, which is entered in the measuring book, according to their thickness and description, viz., inch deal common steps, risers, and carriage.

1¼ inch deal second best, steps, risers, and carriage, with moulded nosings, close or cut string; or,

1¼ inch deal second best, S R & C M nosings, mitred to receive brackets or string boards and return nosings, and dovetailed to receive balusters.

1¼ inch clean deal, do. do.

1¼ inch clean deal, S R & C, to geometrical stairs on a circular plan, the risers mitred to the string board.

VALUATION OF CARPENTERS' AND JOINERS' WORK.

Memoranda.

50 cubic feet of timber equal one load.

100 feet superficial equal one square.

120 deals are called one hundred.

A reduced deal is 1½ inch thick, 11 inches wide, and 12 feet long.

120 12 ft. 3 in. deals equal 5⅔ loads of timber.

400 feet superficial of 1½ inch plank or deals equal one load.

Planks are 11 inches wide, deals 9 inches, and battens 7 inches.

A square of flooring requires—

	Number of 12 ft. boards.
Laid rough	12¼
Do edges shot	12½
Wrought and laid folding	13
Do. straight joint	13½
Do. do. and ploughed and tongued	14

	Number of 12 ft. battens.
One square of wrought folding floor requires	17
Do. straight joint	18

WEIGHT OF TIMBER.

39	cubic feet of	oak	equal	1 ton.
65	,,	fir	,,	do.
66	,,	deals	,,	do.

60	cubic feet of elm	equal to	1	ton
51	„ beech	„	do.	
45	„ ash	„	do.	
34	„ mahogany	„	do.	

CALCULATION, showing the method of ascertaining the VALUE of a CUBE FOOT of FIR or other timber from the prime cost prices:—

	£	s.	d.
Fir timber at per load, say	5	0	0
Carriage (according to distance)	0	5	0
Sawing on an average	0	10	0
	5	15	0
Waste in converting, $\frac{1}{10}$	0	11	6
	6	6	6
20 per cent profit	1	5	$3\frac{1}{2}$
	7	11	$9\frac{1}{2}$

$$\frac{£\ 7\ 11\ 9\frac{1}{2}}{50} = 3s.\ 0\frac{1}{4}d.$$ per foot cube.

The constants in the following tables are to be multiplied by the rate of wages for a carpenter per day.

LABOUR AND NAILS TO ROOFS.

At per square of 100 superficial feet.

	Labour. Days.	Nails. s.	Nails. d.
To common shed roofs, one story high	.650	2	0
Do. do. with purlins	.800	2	0
If two stories, add	.084		
If three do. add	.169		
Common span or valley, with purlins and rafters two stories high	1.000	2	0
If three stories, add	.084		
Framed roofs, with collars dovetailed into sides of rafters, notched to receive purlins, and filled in with common rafters	1.906	3	6
Roofs framed with principals, king posts, purlins, braces, and common rafters	2.940	4	0
Do. do. with king and queen posts,	3.170	4	0
Common kerb roofs on one side	1.125	2	0
If two sides, add	.084		
If three sides, add	.169		
If above two stories, add	.100		

LABOUR AND NAILS TO NAKED FLOORS.

At per square of 100 superficial feet.

	Labour days.	Nails. s.	d.
Ceiling floors, joists only	.584	1	6
Do. framed with tie-beams	.834	1	9
Do. with binding and ceiling joists	1.000	1	11
Ground joists, bedded but not framed	.500	1	6
Do. pinned down on plates and framed to chimneys	.836	1	6
Single framed floors trimmed to chimneys and stairs	1.050	1	9
If above 9 in. deep, add	.169		
Framed with girders and cased bays	1.700	3	0
Framed with girders, binding, bridging, and ceiling joists	2.500	4	0

LABOUR AND NAILS TO QUARTER PARTITIONS.

At per square of 100 superficial feet.

Common 4 in. partitions	.900	1	3	
Do. 5 in. do.	1.050	1	6	
Do. 6 in. do.	1.100	1	6	
Truss framed with king posts	1.736	1	6	
Do. with king and queen posts	2.000			

If oak, extra one-third.

LABOUR ON FIR TIMBER.

At per foot cube.

	Days.
Cube fir bond	.063
Do. framed	.126
Do. truss framed	.168
Do. framed and chamfered	.168
Do. wrought and framed	.210
Do. do. and rebated	.252
Do. W, F, R, and beaded	.294
Do W, F, R, and D beaded	.336
Do. proper doorcases	.378
Planing fir per foot superf.	.014

Bond timbers, wall plates, wood bricks, pole and kerb, &c., are all to be under the head of bond.

CALCULATION, showing the method of finding the VALUE of DEALS or BATTENS from the prime cost prices.

	£	s.	d.
Prime cost per hundred of 12 ft. 3 in. deals, say .	35	0	0
Carriage according to distance	0	10	0
	35	10	0
20 per cent profit	7	2	0
£ 42	12	0	
$\frac{42\ 12\ 0}{120}$ = 7s. 1d. to be allowed in day-bills for each 3 in. deal	0	7	1
In measured work, allow for waste, $\frac{1}{10}$. . .	0	0	$8\frac{1}{2}$
	0	7	$9\frac{1}{2}$

In calculating the value of deals in thicknesses, add the value of the sawing, according to the number of cuts.

Every rise and fall of 9*l.* per hundred, will increase or diminish the price of deals as near as possible, per foot superficial, 1*d.* per inch in thickness. This rule will be found sufficiently correct for practice where the quantities are not large; where they are, the exact calculation should be made.

LABOUR ON DEALS, AT PER FOOT SUPERFICIAL.

In order to facilitate the fixing of proper prices for the labour on deals, at per foot superficial, the different descriptions of work which have always been considered of equal value, are classed together, by which the system adopted for valuing the various sorts of labour on deals, will be rendered more simple and easy; over the column in which is inserted each kind of work of equal value, is placed the decimal which, multiplied by the rate per day allowed for a carpenter at the time and place where the work is performed, will show the fair and equitable price to be allowed.

	No. 1.	No. 2.	No. 3.	No. 4.
For deals from ½ to 1½ in. thick	.009	.019	.027	·037
For deals from 2 to 3 in. thick . . .	.013	.027	.037	.049
	Edges shot. Plugged. Jacked. Rounded.	Labour and nails. Planing on each side. Grooved. Rebated. Ploughed & tongued. Framed. Battened. Mitred. Scribed. Backed. Throated. Clamped. Beaded.	Cut circular.	Cut standards Sunk Shelves. Scolloped. Ledged. Dovetailed.

BATTENING, PER SQUARE.

	Labour. Days.	Nails. s.	d.
¾ in. to 1¼ in. 12 in. from centre to centre . .	.590	2	0
If plugged to walls, add	.170	1	0
Extra for wall hooks.			

WEATHER BOARDING, PER SQUARE.

Rough	.420	2	6
Ditto splayed edges	.680	3	0
Wrought	1.000	3	3
Ditto and beaded	1.255	3	6

ROUGH BOARDING, PER SQUARE.

¾ in. deal, rough	.500	2	6
Do. . edges shot	.667	3	0
Do. . ploughed and tongued . . .	.750	3	0
Inch deal, rough	.542	2	9
Do. . edges shot	.709	3	0
Do. . ploughed and tongued . . .	.918	4	0
Whole deal, rough	.584	3	0
Do. . edges shot	.750	3	6
Do. . ploughed and tongued . . .	1.042	4	0
1½ in deal, rough	.667	3	0
Do. . edges shot	.862	3	6
Do. . ploughed and tongued . . .	1.167	4	0

DEAL FLOORS, PER SQUARE.

Inch, rough edges shot	.765	2	6

	Labour. Days.	Nails. s.	d.
Do. wrought folding	1.180	2	6
Inch, wrought folding straight joint	1.500	3	6
Whole deal, rough edges shot	.840	3	0
Do. wrought folding	1.255	4	0
Whole deal, wrought straight joint, splayed headings	1.760	4	6
Do. do. dowelled	3.170	8	0
1½ in. deal, rough edges shot	.920	3	0
Do. wrought folding	1.340	4	0
Do. do. straight joint, splayed heading	2.000	4	6
If ploughed and tongued headings, add	.295		
If ploughed and tongued edges, add	.510		
For tongues to edges of boards, add	.840		

BATTEN FLOORS, PER SQUARE.

Inch, wrought folding	1.500	4	6
Do. straight joint, splayed headings	1.792	4	9
1¼ in. wrought folding	1.667	6	0
Do. straight joint, splayed headings	2.167	6	3
Do. dowelled	4.167	10	0
If ploughed and tongued headings, add	.431		
If ploughed and tongued edges, add	.750		
For tongues to edges of boards, add	1.250		
If battens less than 5 in., add	.334		

FRAMED GROUNDS, PER FOOT SUPERFICIAL.

	Labour and Nails.
Common framed grounds	.063
1 in. do. ploughed for plastering	.070
1¼ in. do. do. do.	.076
1½ in. do. do. do.	.083

SKIRTINGS, PER FOOT SUPERFICIAL.

Plain skirting	.037
Do. raking cut to steps	.070
Torus skirting	.065
Do. raking cut to steps	.085

GUTTERS AND BEARERS, PER FOOT SUPERFICIAL.

Inch or whole deal	.076

DOOR LININGS, PER FOOT SUPERFICIAL.

	Labour and Nails.
Plain single rebated	.056
Do. and beaded	.063
Do. double rebated	.070
Do. do. and double beaded	.077
Square framed jambs, each in 2 panels and soffit in 1 panel	.105
If bead butt, or moulded, add	.013
Bead flush, or quirk moulded	.027
Raised panel and moulded	.042
For every extra panel if square	.021
Do. flush or moulded	.027
If double rebated	.021
If double beaded	.013

LEDGED DOORS, PER FOOT SUPERFICIAL.

1¼ in. rough edges shot	.065
Add,	
If ploughed and tongued	.013
If ploughed and beaded	.021
If wrought each side	.013
If braced	.027
If hung folding	.021
If 1 in. thick	.013

FRAMED PARTITIONS, PER FOOT SUPERFICIAL.

1½ in. square framed	.065
2 in. do.	.076
Add,	
If B B or moulded	.027
If B F or quirk moulded	.042

DEAL MOULDINGS, FIXED COMPLETE.

Common mouldings	.128
Add, if quirked	.028

The materials for mouldings in deal will be found as near as possible of the same value as the labour. Small mouldings may be measured at per foot run, and valued according to the girt and form.

DOORS HUNG COMPLETE, PER FOOT SUPERFICIAL.

Two panel square framed	.070
Add, for every additional two panels;	

	Labour and Nails.
If framed square,	
For 1½ in. deal	.019
2 in. do.	.021
2½ in. do.	.027
If framed B B and square,	
For 1½ in. deal	.021
2 in. do.	.024
2½ in. do.	.027
If framed B F and square,	
For 1½ in deal	.027
2 in. do.	.037
2½ in. do.	.042
If framed Q^k. O G and B^d. and square, or Q O^v. and B^d. and square,	
For 1½ in. deals	.021
2 in. do.	.024
2½ in. do.	.027
If double margins 4½ in. wide	.021
Do. 5½ or 6 in. do.	.042
Hung folding	.013

WINDOW LININGS, PER FOOT SUPERFICIAL.

Inch deal two panel square framed back linings	.101
If B B or moulded, add	.013
B F or quirk moulded, add	.021
For each panel above two, if square	.021
Do. do. if moulded	.027
If splayed	.007

WINDOW BACKS, ELBOWS, AND SOFFITS, PER FOOT SUPERFICIAL.

Inch deal, plain keyed or two panel square backs	.085
Do. two panel square backs, elbows and soffits	.098
Add for each panel above three,	
If splayed	.010
If bead butt or moulded	.013
B F or quirk moulded	.021

BOXINGS TO WINDOWS, PER FOOT SUPERFICIAL.

Framed, rebated, and beaded boxings	.101
Splayed F R and beaded boxings	.120

INSIDE WINDOW SHUTTERS, PER FOOT SUPERFICIAL.

	Labour and Nails.
¾ in. deal clamped flaps in one height	.120
Inch do. two panel square in one height	.125
For every panel above two add,	
If framed square	.022
If B B or moulded	.022
B F or Q^{k}. moulded	.026
Q O G & b, or Q O & b & square	.026
For every extra height add	.013

SASHES AND FRAMES HUNG COMPLETE, PER FOOT SUPERFICIAL.

Sashes—	
1½ in. deal ovolo sashes	.049
Do. wainscot or mahogany	.070
If 2 in. or 2½ in. sashes deal, add	.021
If do. wainscot or mahogany, add	.028
If astragal and hollow in deal, add	.013
If do. in wainscot or mahogany, add	.021
Frames—	
Deal cased frames O S sills, D P P B & P S, S hung	.070
If prepared for 2 or 2½in. sashes, add	.013
If prepared with wainscot or mahogany P P B^{ds}. & P slips add	.085
If for 2 or 2½ in. sashes add	.019
If double hung, add	.013

To find the value of sashes and frames, add to the above for labour and nails only, the amount of materials expended.

STAIRCASES, PER FOOT SUPERFICIAL.

Common steps and risers and two fir carriages	.070
Do. moulded nosings and close strings	.098
Do. do. mitred to cut string-boards and dove-tailed to balusters	.127
Add,	
If winders circular one end	.042
Do. circular two ends	.085
Do. geometrical with wrought and blocked carriages	.056
Riser tongued to step bottom edge	.021
Do. do. both edges	.042
Feather tongue joints	.021
Add for each—	
Quarter curtail glued upright	.667

	Labour and Nails.
Do. blocked and veneered	1.167
Proper curtail step and riser	3.334
Returned moulded nosing	.250
Do. circular	.417
Plain cut bracket	.250
Do. circular	.417
Housing to step and riser	.098
Do. to winders	.125
Do. to moulded nosings	.167
Do. to do. circular ends	.459

OUTSIDE STRINGS TO STAIRS, PER FOOT SUPERFICIAL.

Whole deal, plain	.084
Do. sunk	.098
Do. sunk and moulded	.112
Do. do. cut	.127
Do. do. mitred to risers	.140

If wreathed,—four times the above.
If ramped,—once and half do.

WALL STRINGS, PER FOOT SUPERFICIAL.

Plain and plugging	.080
If moulded, add	.021
If rebated for plastering, add	.028

DADOS, PER FOOT SUPERFICIAL.

Proper dado, with dovetailed keys, joints secured with slips, and dovetails hung to grounds by keys grooved into do. and dado	.070
Add,	
If raking scribed to steps	.019
Do. to moulded nosings	.021
If base grooved into floor	.009
For each external mitre beyond two in the room	.228

If circular on the plan,—double the above.
If wreathed do,—treble do.

COLUMNS AND PILASTERS PER FOOT SUPERFICIAL.

	Labour and Nails.
1¼ in. deal plain pilasters, properly glued and blocked	.112
Do. do. diminished	.153
1¼ in. deal diminished columns, properly glued and blocked, under 14 inches diameter	.420
Do. do. above do.	.350
Add for	
Arris or deep fluting to pilasters, one inch wide	.021
Do. two inches wide	.028
Do. three inches wide	.042
Arris or deep fluting to columns, one inch wide	.027
Do. two inches wide	.042
Do. three inches wide	.056
Straight grooves to columns	.021
Headings to flutes to do.	.070
Straight grooves to pilasters	.013
Headings to flutes to do.	.042

SECTION IV.—*Sawyers' Work.*

The charges for sawyers' work are often very inconsistent, and differ widely in various parts of the country.

The proper mode of valuing the labour on sawing fir or any other kind of timber is by the square of 100 superficial feet, the price depending on the usual rate of wages and the hardness of the timber.

Sawing to old timber is usually charged double, on account of the extra labour occasioned by nails, &c.

Small scantlings may be charged by the foot run.

Planks, deals, battens, and flat cuts, according to their length, at per dozen cuts.

And all other descriptions of sawyers' work may be valued in a similar manner, according to the circumstances of the case.

SECTION V.—*Stone-Masons' Work.*

There is a variety of opinions respecting the manner of measuring stone-masons' work, both in taking the dimensions for the stone, and also for the labour. It certainly requires more practical knowledge of the operative or working part of the business

than any other trade, to determine correctly between these conflicting opinions. The following rules may be considered sufficiently explanatory of the principle on which the practice is governed or founded.

In measuring cube Portland or other stone; all stones that are worked square should be taken accurately as they come from the saw to the banker, of course including the parts laid on or pinned into the walls. But as bevelled or irregularly formed stones cannot be converted without more waste than square ones, the dimensions should be taken so as to make a fair allowance for such additional waste, particularly as the solid contents of all the different descriptions of Portland stone, whatever shape the stones may be worked to, are abstracted under the same head, (viz., cube Portland,) and therefore should be of the same value; but which cannot be the case, unless the extra waste in the bevelled stone, &c., is allowed for in taking the dimensions. When this is done, it is only requisite, in estimating the prime cost, to calculate for the waste as if all the stones in the building were cut and worked square. If this method were not adopted, it would be requisite, in ascertaining its real value, to make so many different heads in the abstract for cube Portland, as there are different shaped or bevelled stones, accurately describing each; when the calculations for waste, and of course the price, must vary according to each particular form, the trouble of which would be endless, and without any advantage; indeed, it would come to the same thing, viz., making the necessary allowances for waste, according to the form of the stone. Bevelled or arch stones should be taken about one-sixth above the mean dimension to allow for waste.

In measuring the cubic contents of spandrel steps, some difference of opinion exists as to the best method of taking the requisite dimensions. The following three methods are in common use, viz.:—

1st. Take the length of the step by its extreme width, and by the whole height of the riser measured from tread to tread.

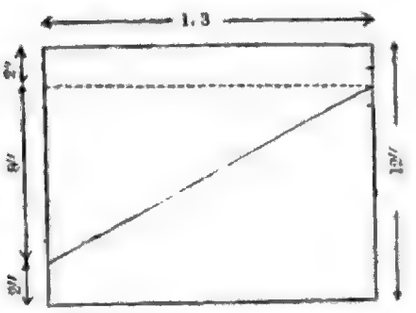
2nd. Take the length of the step by the extreme width from the nosing of the tread to the acute angle, and by half the height of the riser taken from the top of the tread to the acute angle downwards.

3rd. Take the length of the step by its extreme width, and by three-fifths of the depth of the riser taken from the top of the tread to the acute angle downward.

A better way than either of the above methods is to take the

length of the step by a dimension found as follows, allowing half an inch on each step for waste.

1	3	width of step.
	6	2 base of rectangle.
	——	4 half do. of triangle.
		—
		6



This gives

5	0	
1	3	
	6	
——	3	1 6 as before.

In measuring winders, the content may be found in the same way, taking the extreme length of the step by the mean sectional area, making due allowance for waste.

The labour on the under side to be taken as circular sunk work.

All stones exceeding three inches thick should be taken as cube measure, with the labour, &c., on do.

All stone, three inches thick and under, should be taken as slab, at per foot superficial.

The usual custom has been to measure in such edges as are worked and show fair. Objections have been made to this practice, and with some degree of justice; but it will make very little difference, if the edges of thin slabs are measured separate, and a fair price allowed for the labour; and for cutting into narrow pieces for mantles, jambs, &c., it would be nearly equal to the value of the stone; but in thick slabs the same argument will not hold good; and, therefore, as the object in measuring work should be to ascertain its real value, and allow only a fair remunerating price, it appears more correct to measure the labour on the edges at per foot run, offering a fair price, according to their thickness, instead of entering it as stone. An extra price should be allowed for very large scantlings, also for hoisting stones on exceedingly high buildings, according to circumstances.

LABOUR ON PORTLAND OR OTHER STONE.

In measuring the labour of working Portland stone, the principal difference of opinion arises in determining what faces or beds should be taken as plain work. In superior work, a plain face must be taken previous to measuring the sunk, moulded, or other work, when the mould could not be applied without first making that plain face. There cannot be much difference of opinion in taking the other labour, such as sunk work, moulded work, circular-sunk or circular-moulded work, &c., which must be girt as it appears when the work is finished, but which is not always the case with the plain work; and therefore it is requisite to know the manner in which the work is executed, to form an accurate conclusion, and to do justice to the workman in its measurement.

WEIGHT OF STONE.

Purbeck stone .	14 cubic feet	weigh one ton.	
Portland . .	16 „	„	do.
Bath . .	17 „	„	do.
Yorkshire . .	15 „	„	do.
Granite . .	13½ „	„	do.
Marble . .	13 „	„	do.
Purbeck paving .	50 feet superf.		do.
Do. step 13 by 6½	25 feet run		do.

VALUATION OF LABOUR.

Table of Constants for the different descriptions of Mason's Work.

N.B.—The factor to be applied is the rate of wages for a mason per day.

	Days.
Labour, squaring and laying new York or Purbeck paving per foot superficial	.021
If in courses, add	.010
Labour on Portland or similar stone per foot superficial. Sawing to be taken as half plain work.	
Plain work to bond stones . per foot superf. . .	.140
Do. to beds and joints . do. . . .	.181
Do. rubbed face . . do. . . .	.209
Do. do. circular . . do. . . .	.291
Sunk work rubbed . . . do. . . .	.250
Do. do. circular . . do. . . .	.313
Moulded work rubbed . . do. . . .	.292
Do. do. circular . . do. . . .	.417

		Days.
Circular work to shafts of columns having the neck moulding or part of the base worked in the same stone	per foot superf.	.334
Circular circular or spherical work to domes or balls	do.	.500
If rubbed, add extra	do.	.049
Taking up, squaring, and relaying old paving	do.	.042
Add, if in courses	do.	.015

Labour on Statuary or Vein Marble,

Including Sawing, Working, and Polishing.

Plain work	per foot superf.	.875
Circular work	do.	1.250
Sunk work	do.	1.667
Moulded work	do.	2.334
Circular sunk work	do.	2.334
Circular moulded work	do.	3.000

ON OLD WORK.

Old vein marble chimney reset	per foot superf.	.125
Do. do. squared and reset	do.	.167
Do. do. sanded, grounded, and squared	do.	.209
Do. do. and reset	do.	.250
Do. do. cleaned and reset	do.	.250
Do. do. sanded, polished, and reset	do.	.375
Do. do. sawed, sanded, polished, squared, and reset	do.	.626

In the west of England, and all the counties in which stone is abundant, it is usual and customary to build with the rough stone of the country, and the practice generally is to measure the walls by the perch of 18 superficial feet, supposing them 24 inches thick; to which thickness all the walls, whether more or less, are reduced by multiplying the superficial contents by the thickness in inches, and dividing them by 24; or they may be reduced to the cube perch of 36 feet: but some regulate the prices per perch, according to the thickness of the walls.

In measuring the work, some contend to girt the quoins and all projections, as they say, to pay them for the extra trouble in working and setting the stones; but this should not be allowed, except for labour only; and even then it is much fairer to measure the quantity of walling as it is, and make a proper allowance for the extra labour, either in quoins, chimney breasts, flues, reveals, &c.

SECT. VI.—*On Measuring Plasterers' Work.*

Plasterers' work is taken superficially, and valued by the square yard of 9 feet.

If cornices are round the room, take the ceiling only to half the projection of the cornice, or one projection in and one out; or measure the ceilings clear of the cornices, and take the whole of their projection as lathing and pricking up.

If the cornices are bracketed, measure the ceilings clear of the cornice.

The sides of the room should be taken from the ground, through the bed-mould, or half the height of the cornice.

If on brick, or bracketed, take them only to the bottom of cornice.

In taking the length of cornices, measure the size of the room, taking one projection in and one out, and girt them from the mould, or from the ceiling to the wall line.

Number all the angles in the room above four, as extra.*

In taking cornices where there are coves, take the coves as superficial of cove to cornices, and allow 1 inch extra on the girt of the cornice for the return of the mould on the cove.

All enrichments to be taken separately.

Friezes, under the cornice, must be taken as superficial of plain floated frieze. A floated ground must be taken under all enriched friezes.

If cornices are run to old ceilings, a screed must be allowed.

Enriched friezes, ceilings, or soffits must be measured first as plain work, and then the enrichments taken separately at per foot run, and a price fixed, according to their description and value.

All circular mouldings and enrichments to be taken one face in and one out.

Take first the ceiling through the reeds.

Second, length of cove above the cornice by 2 ft.

Third, do. of moulded cornice by 1 ft. 2 in., being 1 in. extra for top on cove.

Fourth, do. of plain floated frieze by 6 in.

Fifth, do. of moulded architrave by 8 in.

* The present practice, however, of making four additional mitres to carry the cornice round a projecting chimney, is as absurd a deformity as it is an extravagant waste. Even the architects of the last generation had the wit to keep their ceiling a simple rectangle, by arching in brick the recesses on each side of the chimney.

Sixth, length of moulded reeds by 9 in.

Reveals to windows taken at per foot run, price according to width.

Valuation of Plasterers' Work.

Calculation of Materials.

1 hundred of lime = 25 strike bushels (old measure).

	Materials.	Labour.
100 yards of render set require	$1\frac{1}{2}$ hd. of lime. 1 double load of sand. 4 bushels of hair.	Plasterer, labourer and boy, three days each.
130 yards of lath, plaster, and set require	1 load of laths. 10,000 nails. $2\frac{1}{2}$ hd. of lime. $1\frac{1}{2}$ dble. lds. of sand. 7 bushels of hair.	Plasterer, labourer and boy, six days each.

LATHING.

1 bundle of laths and 384 nails will cover 5 yards.

RENDER ONLY.

$187\frac{1}{2}$ yards require . .	$1\frac{1}{2}$ hd. of lime. 2 double loads of sand. 5 bushels of hair.

Floating requires more labour, but not more than half the quantity of stuff as rendering.

SETTING ONLY.

375 yards require . .	$1\frac{1}{2}$ hd. of lime. 5 bushels of hair.

20 per cent. is always allowed on the prime cost of the materials.

Calculation of Labour.

The decimal is to be multiplied by the rate of wages for plasterer, labourer, and boy, per day.

	Days.
Rough render	.019
Floating do.	.021
Setting	.016
Lathing	.019
If circular work, add on the lathing and also on each coat of plastering	.008
If to groins, add as above	.010

Sect. VII.—*Ironmongery.*

Nails are sold by weight, and charged by the hundred. Screws at per dozen. Iron bolts and screws at so much each. Brass flush bolts at per inch. Pulleys each, according to diameter. Hinges and screws at per pair. Locks at so much each.

Twenty per cent. profit is allowed on the prime cost of all ironmongery.

Measurement of Iron-work.

Cast iron in girders, story-posts, columns, &c., is charged by the ton or the cwt.

Moulds are generally charged extra, if out of the common run.

Articles in common demand, as cast-iron water pipes, gutters, &c., are sold by the yard, according to diameter.

Cast-iron in railings, gratings, casements, brackets, &c., is charged by the pound, according to the nature of the work.

Wrought-iron in chimney-bars, railings, hand-rails, shoes to piles, &c., is charged by the pound.

Sect. VIII.—*Painter's Work.*

In measuring painters' work, all work not cut in on both edges, must be taken, including edges and projections, at per yard square of 9 feet.

Work cut in on both edges, as skirtings, cornices, shelves, &c., are measured at per foot run.

Ornamental work first taken as common, and then superf. of labour to ornaments at per foot superf. or run.

Sash frames, window lights, casements, bars, dormers, frontis-pieces, chimney-pieces, &c., numbered and valued at each. Sash squares at per doz.

Iron or wood railings, balusters to stairs, &c., are measured on both sides as solid work, to allow for the extra trouble of painting round the bars, rails, &c., at per yard.

If ornamented, add extra one face in the width of such ornamental parts.

If ornamented turned balusters, also add one extra face as far as the turned work goes.

Handrails, &c., grained mahogany, first measure them in with the balusters, and then per foot run for graining.

Soffits to windows per foot run.

Letters or figures numbered and valued at per inch in height.

Windows and doors are measured thus :—

Windows.

ft.	in.	ft.	in.	
11	0			Window front.
5	5			
				ft. in. ft. in.
				7 6 4 6
				0 4 edges. 1 6 boxings and edges.
7	10			Shutters 7 10 6 0
6	0			
				ft. in.
				7 6 If the backs 10 6 } linings } viz 26 3
				7 6 are cut away 10 6 } 1 2
20	3			Linings 0 9 the linings 4 6 soffit
1	2			4 6 must be measured 0 9 elbows
				to the floor 26 3
				20 3 thus:
				7 6
				3 9
22	6			Beads varnished, supposing them to be mahogany or wainscoat sashes and beads 11 3
				11 3
				22 6
				12 squares varnished.
				1 locking bar.
				1 6 boxings.
				0 6 edges.
				Some only allow the shutters to be taken thus : 2 0
				3 9 shutters.
				5 9 instead of 6 feet.
				N 1 frames.
				The outside of window would be taken as . . . 1 dozen of squares.
				1 sill, if the stone still is painted.

Doors.

2)7	0			Door fronts for both sides . 4 0 } projection of archi-
4	4			0 4 } traves.
				4 4
				6 6
				6 6
16	0			Linings 3 0 0 6 } edges of door and
0	8			0 2 } rebates.
				16 0 0 8

Valuation of Painter's Work.

Calculation of Materials.

45 yards of work, 1st coat, including knotting, stopping, and every preparation requisite for the second coat, will require . . .	5 lbs. of white lead. 5 lbs. of putty, litharge, &c. 1 quart of oil.
Second and following coats .	5 lbs. of white lead. 1 quart of oil.

20 per cent. profit is always allowed on the prime cost of the materials.

Calculation of Labour.

The decimal to be multiplied by the rate of wages for a painter per day:—

First coat, including stopping, &c.	.027
Second and following coats	.019

The above data will suffice for the valuation of common work, for which alone it is possible to lay down any rules, as the value of decorative work, as graining, imitations, &c., depends upon the ability of the artist, and the manner in which the work is executed.

Sect. IX.—*Glaziers' Work.*

In measuring glaziers' work, the dimensions must be taken between the rebates, and all irregular panes the extreme size each way.

The price per foot must be calculated from the prime cost per crate, allowing for carriage and 20 per cent. profit. The larger the panes are, the more difficulty, risk, and waste; consequently the price should increase in the following proportions:—

	ft.	in.		ft.	in.		
Panes whose superficial contents are . . . under				2	0	at per foot.	
Do. do. do.	from 2	0	to 2	6		add 2*d.*	Above the squares whose contents are under 2 feet.
Do. do. do.	do 2	6	to 3	0		add 4*d.*	
Do. do. do.	do 3	0	to 3	6		add 6*d.*	

A CRATE OF CROWN GLASS

Contains 12 tables of the best, at per crate
„ 15 „ seconds „
„ 18 „ thirds „
„ 18 „ fourths „

Each table is from 4 ft. to 4 ft. 6 in. diameter: some tables

may be cut to within 2 in. of the centre, others not nearer than 4 inches.

	ft.	in.
Supposing a crate to be 4 ft. 6 in. diameter, and that it may be cut to 2 in. from the centre, the quantity of glass that may be cut from it, including the triangular pieces, will be	14	2
If only 4 ft. diameter, and cannot be cut nearer that 4 in. of the centre	10	10
	25	0
And deducting the triangular pieces, which are of very little value	2	6
We have as the available contents of the two tables .	22	6
The average contents per table	11	3

Taking the sizes of squares that will cut to the most advantage: but as squares of all sizes must be cut from the tables as they are wanted, the average produce per table is not more than 10 ft. superficial.

Labour and putty per foot may be found by multiplying the rate of wages for a glazier per day by the decimal .110.

Ex.—To find the value per foot of glazing, with best Newcastle crown glass, or any other kind of glass:—

	£	s.	d.	
Prime cost of crate (12 tables) . .	0	0	0	
Carriage, &c.	0	0	0	
	0	0	0	
20 per cent. profit	0	0	0	
Divide by No. of feet the crate will produce, for best glass . . 120)	0	0	0	
	0	0	0	per foot:
Labour and putty	0	0	0	
Total per foot	£0	0	0	

SECT. X.—*Paper-Hanger.*

A piece of paper is 12 yards long, and when hung, 20 inches wide. Twelve yards running measure is equal to $6\frac{3}{4}$ square yards, or 60 feet superficial; therefore divide the superficial feet by 5, which will give the number of yards, and these divided by 12 will give the number of pieces of paper.

It is usual to allow one piece in seven for waste.

Constants of Labour.

These constants represent the time requisite to perform a given quantity of work, of the kind specified, in days and decimal parts of a day; the factor to be applied, being the rate of wages per diem for one or more men, according to the nature of the work.

These decimals are calculated, in all the trades, for the price per day allowed the master in his day bills, consequently, with his profit thereon, being the only rate that can be ascertained, the master, of course, paying each man per week, according to his abilities and industry; therefore the full value of the labour, including the master's profit, will be found by multiplying the decimal by the rate of wages, as shown in their respective tables. Likewise, in all cases it must be understood that the prices stated in the tables for labour and nails include fixing; and when added to the price of deals, will give the value of the work fixed complete, including labour, nails, and materials, according to the prime cost of materials and rate of wages allowed.

CHAPTER XVII.

THE VALUATION OF ESTATES.

Unlike all the other subjects that have been treated of in this book, this one cannot be demonstrated. The theory may indeed be enunciated, but in the event of a difference of opinion arising, there is no mode of reconciling the variance in a manner that shall place it beyond doubt. The profession of a land valuer is very often confounded with, and designated by, the title of that of the land surveyor. I do not mean to say a land valuer cannot by possibility be also a land surveyor; on the contrary, I am personally acquainted with several brilliant examples of the practice—the successful practice—of both professions; but, as a general rule, the land valuer, most efficient in his calling, is a man who has spent the greater portion of his early life upon land, in the study and practice of agriculture; who has by experience gained such a knowledge of the several treatments which may be most successfully applied to those particular soils that chiefly abound in the vicinity of his agricultural operations, or in the adjoining counties; who is thoroughly acquainted with

the cost of labour and tillages upon these lands, and of the seasons and periods of which advantage must be taken in due course. No one can doubt for a moment that such a man, particularly if he be more intelligent than the generality of his order, is the most fitting person to exercise a profession requiring a practical knowledge of all these things as its chief ground work. But then to call such a man a land surveyor is a libel upon a very different profession—a profession moreover which requires quite as long practice as the other to make its possessor thoroughly efficient; and, therefore, the two are not likely to be perfectly acquired by the same person in very early life. I said I knew of one or two brilliant examples of the exercise successfully of the two professions by the same persons. These gentlemen, whom I have in my mind, are men of excellent abilities; were originally educated as land surveyors, at which, as it is their great pride to boast, they for several years earned a maintenance. During that time each kept his attention steadily riveted on the different kinds of agriculture practised in the varied localities and counties over which his legitimate profession called him; observed with interest every variation of treatment to which land, apparently of the same nature, but in different counties, was treated by different farmers; investigated the reasons of such apparent anomalies by all possible references to climate, soil, and pecuniary consideration, until, I have no hesitation in saying, he gradually and contemporaneously with the exercise—the profitable exercise—of the profession of land surveying for a sufficient number of years to be thoroughly experienced and grounded therein, entirely qualified himself to conduct the profession of land valuing.

Such is the prospect and such the possibility of a land surveyor acquiring in time a competent knowledge to act as a land valuer. Another way of effecting this object has been adopted, though not, as I believe, successfully, nor without considerable pecuniary sacrifice. The land surveyor has taken a farm whereon he of course has gained knowledge by experience, but then the knowledge thus acquired has been of necessity limited, and too often the harass and worry of the farm must have distracted his attention from the proper exercise of land surveying, or the duties of the latter calling must have been located in a quarter many miles from home, at the same time that the business of the farm required the presence of the master.

Now let us take a view of our experience among the several instances of persons who are legitimately land valuers, but who also practice as land surveyors. I do not hesitate for myself to state, that I am unacquainted with any single instance in which a land

valuer, qualified either by his experience as a farmer, or by early education as a valuer, has subsequently adopted land surveying with any pretensions to the title of a land surveyor, or with the smallest atom of success. He may, as I am aware by an example I have in my mind, acquire a rudimental knowledge that may enable him to map a field, a farm, or a small estate. But while as a valuer he would, the moment he entered a field, detect a gravelly brow subject to burn, or slovenly farming, and the presence of couch, a glaring error in a plan, that would at once rivet the attention of the experienced surveyor, would entirely escape his notice. Thus he might be able to define within a shilling an acre the value of the land, but by attempting the exercise of both professions, the eminent knowledge in the one would be entirely nullified by some error of two or three acres in the quantity, which an acquaintance with the other would have corrected.

I knew an instance of a man who was brought up as a tradesman in London, and who, much to his credit, so industriously pursued an honest calling, that at the age of 40 he had saved a sufficient sum of money to retire from his business into the country, where he took a farm. Being somewhat intelligent, he announced himself as a land valuer, and very shortly afterwards a land surveyor. Some ten years after, a gentleman, who knew nothing of the qualifications of a land surveyor, had occasion to employ a number of surveyors as witnesses in a law suit; among them came this one. Of course the opposing counsel was duly instructed as to the qualifications of the witnesses, and in cross-examination endeavoured to furnish the jury with the information he himself possessed. In vain our witness appealed to his age, and his ten years' residence on his farm. The counsel was perfectly willing to accord to him the benefit of his experience in his London calling, and on his farm; but unless said he, he were a heaven-born surveyor, or could point to some work which he had performed, he could not allow a jury to attach importance to his evidence as a surveyor. The very age upon which he relied but aggravated his insufficiency; since three years spent in the acquirement of correct first principles in any science are better than ten years bungling in erroneous ones. Notwithstanding this little check our friend continued his career, his greatest ignorance being apparent in his want of information that his own works were at all below par.

The tendency of my remarks has been to show that land surveying can only be learned in youth, and thorougly acquired by considerable subsequent experience. That a land valuer cannot take it up at pleasure and exercise it any more than a lawyer can prac-

tise medicine, or the surgeon carry on the law. But that a clever land surveyor may by a long course of industry become a qualified land valuer. And the object I have had in view in making these observations has been to promulgate correct ideas upon the subject, affording employers the means of forming an opinion of the qualifications of men to whom they entrust their interest, and furnishing a hint to those who may select these professions for their sons, as to the proper course to pursue to conduce to future advantage.

The greatest amount of success is attained in matters of valuation by the joint co-operation of two professional men; the one being a competent valuer, the other a qualified surveyor; the practical knowledge of the one is considerably assisted by the science of the other, and appreciable advantages ensue. It is much to be pitied that so much jealousy exists between the two professions, which militates to the injury of both.

The practice adopted by most valuers is to assume that they are aware on inspection, without any enquiry, of the worth of an acre of land per annum. Now this is in many instances an erroneous and in all cases a vicious theory. I will endeavour to illustrate my meaning by an example: Assume a valuer to have a farm for which he pays, he believes, from experience, of its productiveness, and we will consider equitably 20*s.* an acre as rent; therefore, directly he comes to similar land in making a valuation, he says, this is worth 20*s.* an acre. But now just assume his own land to be situated in a parish where the local burdens amount, on an average, to 3*s.* in the pound, while the land he is valuing is situated in a parish where those burdens are 6*s.* in the pound. The calculation then stands thus, his own land which he has taken as his standard of value is worth in the aggregate of rent and rates 23*s.* per acre, which, when reduced by the amount of rates, exhibits 20*s.* as its net value. Now reduce the aggregate value of the land he is valuing by the amount of the rates, and we shall get but 17*s.* as the net value. The two lands being similar in every respect as to quality, tenacity, and eligibility of situation, but the one being subject to 3*s.* excess of taxation over the other, is to that extent depreciated in value for rental. The difference is doubly apparent if we assume the standard to be worth 46*s.* per acre, rent and rates, or reduced by the amount of the latter at 3*s.* in the pound to 40*s.* Our compared acre of equal fertility upon which the rates are 6*s.* in the pound, would be reduced in value to 34*s.*, so that land otherwise equal in value, but affected by a cause which the generality of valuers entirely disregard, is, when properly adjusted, equitably worth in one parish 40*s.*, in the other only 34*s.*

This comparison is sufficiently accurate for practice, but in reality it is not the actual equity of the case. For the rates of 3*s.* and 6*s.* in the pound are levied on the rental, and therefore the calculation stands as under:—

	£	*s.*	*d.*
Rent at 40*s.* per acre . . .	2	0	0
Rates at 3*s.* in the pound . .	0	6	0
	2	6	0
Rent at 34*s.* per acre . . .	1	14	0
Rates at 6*s.* in the pound . .	0	10	4½
	2	4	4½

The correct adjustment of the latter example would be—

	£	*s.*	*d.*
Rent at 35*s.* 4*d.* per acre . .	1	15	4
Rate at 6*s.* in the pound . .	0	10	8
	2	6	0

In some counties (Surrey to wit,) the acts of husbandry performed on the fallows of the last year are paid for at valuation by the incoming tenant. This is a matter which again affects the rental of land. These valuations of tillages, and what is called tenant right, will be treated of bye and bye; my present purpose is to show how they influence the rent.

I have mentioned Surrey—in that county the valuation of fallows frequently amounts to four pounds per acre, and the dressings to other four pounds. Now, if we take the fallow lands to be one-fourth of the whole farm, we have a sum amounting to 2*l.* per acre all round, to be paid down by the tenant on entering, and there locked up for the whole term, without any advantage or benefit to him, except indeed it is taken into consideration in fixing the rent. Even if it is so, the capital thus expended would be far more useful and remunerative to the tenant than such a reduction of rent.

Therefore we must once more suppose that the land which we assumed to be worth 40*s.* an acre in one parish is not subject to this valuation, but that of equal quality which the excess of local burdens reduced to 35*s.* in the other parish is. And we shall again see how this charge tends to a still farther reduction.

I think no man would take a farm and risk capital in it if he did not expect to get 10 per cent. for the use of his money, so that we

have 4*s.* to deduct from the already reduced estimate of 35*s.* 4*d.* per acre to arrive at the fair rental. Thus—

	£	*s.*	*d.*
Original value	2	0	0
Reduced by excess of local burdens to	1	15	4
Further reduced by interest on money paid for valuation to . .	1	11	4

The cost of production materially influences the value of land. Lands of equal fertility but of different tenacity are of very different values. Indeed if we seek an example among the poorer soils, we shall find that in some cases the cost of labour entirely consumes the value of the produce, leaving nothing for rent, while on a lighter soil, less expensive to cultivate, but of the same fertility, a small rent is deducible.

I think I have said enough to show that the system of valuing lands by "experience only," as it is called, is erroneous; it is indeed comparing the *net* rent of land and not the *gross*, for after all, taxes and outgoings of a similar nature are but rent, expressed by another word.

And this leads me to the consideration of what is rent? It is undoubtedly the surplus that remains for the landlord after all the expenses of cultivation, tithe, taxes, outgoings of every description, tenant's profit, interest for his capital, and provision for wear and tear, and for renewals, have been satisfied out of the value of the produce; and land which leaves no such surplus, is worth no rent for the purposes of agriculture.

The first thing, therefore, which has to be done in entering fairly on the valuation of an estate is to estimate the yearly value of the produce it is capable of yielding under skilful management, and with a liberal but judicious expenditure of capital.

Next to appraise the cost of the labour and other outlays necessary to ensure in the ordinary chances of the seasons the estimated amount of produce. Then the amount of tithe rent charge, and tenant's rates and taxes are matters to be ascertained by enquiry. The tenant's profit should be such an amount of remuneration as a person should receive at the current rate of skilled labour for such an amount of supervision and attention as the farm may require, without any reference to the style in which he lives, whether he dines at one o'clock or five, keeps hunters, or walks to market. The tastes and habits of a tenantry on a large estate may vary immensely, but their rights are identical and equal.

Allowance for wear and tear of live and dead farming stock must also be made. This involves an estimate of the value of the whole stock, and when this is arrived at, a calculation must be made of the probable average length of time within which the whole will be required to be renewed, and the proper proportion thereof for the one year must be placed among the deductions from the value of the produce. The interest on capital must be a fair liberal allowance, according to the current rate of money, subject to risks and casualties; and when all these deductions have been made, the landlord has for the first time an interest in the residue (if any,) as rent.

Our theory, when illustrated, stands thus—

Assume	the value of produce . . .	100
„	the cost of cultivation . .	53
„	Tithe }	10
„	Tenant's rates and taxes }	
„	Tenant's profit	7
„	Interest on capital . . .	5
„	Wear and tear . . .	5
„	Residue rent	20
		100

It was formerly the custom to say that the produce of a farm should carry three rents—one of which was to be apportioned to the landlord, a second to the tenant, and the third to pay expenses. It is hardly necessary to observe that such an apportionment must be very impracticable and ridiculous. Take for example the case of our illustration, where the landlord gets one-fifth only; the tenant rather less than that; and more than three-fifths are absorbed for expenses. I may also observe, that in framing that illustration, the farm I had in my mind was a light land farm; had it been a tenacious clay, the expenses might have been so swollen as to intrench considerably on the surplus rent.

The method of including *farm homesteads* (by which I mean both farm houses and buildings,) in the valuation, has been a much vexed question among valuators. Some omit to consider the homestead at all, alleging that a discretion is exercised in fixing the value of the land: others add so much to their valuation for every 50 acres of land possessing a homestead, omitting to make the addition where no buildings exist. Others, and this is I believe the more common way, profess to value the house and each separate building at its intrinsic value, and add the amount to their valuation of the land.

In my opinion none of these are worthy of imitation. To convert the produce of land a certain number of buildings are requisite, as well as a house for the farmer, and lodging for his cattle. Without these accommodations the farm would not be tenantable, and the value of it would be entirely problematical, as it might be difficult to hire suitable buildings elsewhere; or if they were to be had, the rent might be so excessive as to consume a large portion of the value of the produce. Therefore it appears to me that the only correct way to adopt in practice, is to assume when valuing land, that all requisite building accommodation exists in a convenient position upon the farm, the value of which is included in the estimate of the land. If upon examination the buildings are too small or are inconvenient, a proportionate reduction must be made from the valuation: but if, on the other hand, a surplus number of buildings are situate on the estate, no addition should be made, as the farmer is not benefited thereby; on the contrary, all beyond his actual requirements are so many additional expenses to him in keeping them in repair; unless indeed he can rent some land adjoining the farm that is without a homestead, in which case it would be only fair to charge him with the excess. If lands that have been so valued are found to be without a homestead, then the damage occasioned thereby must be deducted.

When I first promulgated this system of valuing farm buildings among my professional friends, I recommended that the farm houses should be subject to the same arrangement, but a practical difficulty arose with respect to them. The requirements of a farmstead with reference to farm buildings may be defined, and as I have shown, any excess is valueless to the tenant, except under an unlikely or a rare contingency. But it is not so with the house. If a farm has a good house upon it, pleasantly situated, that farm will more readily let than one affording merely accommodation to the farmer; and excess of room in a farm house may be very frequently profitably let. Moreover, a farmer has no right to expect that the profits of his business are to be estimated differently to those of other people, who pay the rent of their houses out of their profits: so that it appears reasonable that while all other buildings are included in the arrangement, and treated as I have suggested, the house should be made the subject of separate and additional valuation.

I have described the mode of valuing adopted in general practice, which assumes the valuator to be possessed of the capability of at once determining the value of a piece of land while he is upon the field without reference to particular circumstances

that may specially affect it. To that practice I take an exception, and say that it is not a correct one. I am fully aware of all the imputations to which I shall be subjected for promulgating ideas contrary to generally accepted customs. I shall be dignified with the title of "Theorist," and many similar appellations. But "theory with practice" has ever been a favorite motto with me, and I have sufficiently considered the matter to know that a sound theory is as requisite in land valuing as in any other art or science.

The only thing that requires to be *estimated* on the ground is the produce the land is capable of yielding, which may be expressed in bushels of wheat or barley, according to the nature of the soil, which should be noted.

I would then advise every valuer to reduce to the same measure (bushels of wheat or barley,) all other items that enter into the computation of the cost of production, out-goings, &c., and to tabulate the results according to his notions of expense and profit, and he will find the arrangement conducing to convenience and advantage.

To illustrate what I mean and what the Tables should be, take the figures in my previous example to represent the produce in bushels of wheat on three acres of land.

We will discuss four cases and tabulate the results. The first shall be in every respect as it stands originally, and shall be supposed to be on light land: the second is supposed to be land of the same density and fertility, but subject to 5 bushels of taxation instead of 10. The third case is heavy land, and the cost of cultivation becomes 70 instead of 53; other charges remaining the same. The fourth and last case is on heavy land, with the same charge of 70 bushels for cost of cultivation, but taxes reduced to 5.

The Table would be thus—

PRODUCE 100 BUSHELS.			
Light Arable Land.		Heavy Arable Land.	
Local Burthens, including Tithe Rent Charge, Rates, and Tenant's Taxes.	Rent in Bushels of Wheat.	Local Burthens, including Tithe Rent Charge, Rates, and Tenant's Taxes.	Rent in Bushels of Wheat.
When amounting to 10 Bushels p. acre	20	When amounting to 10 Bushels p. acre	3
„ 5 „ „	25	„ 5 „ „	8

It will be obvious that a system of Tables of this nature extended to every variety of soil that differs in its cost of cultivation and in fertility, and to all the variations of taxation, would be the most equitable mode of valuing land that could be well devised. The Tables once made would be permanent, as the results show the rent in bushels of wheat, and whether that grain were worth in the market 5, 6, or 7*s.* per bushel, would be equally applicable.

When time permits, it is my intention to calculate, for publication, a series of tables of this nature.

Cottages on a farm should form the subject of an additional item in the valuation, affording as they do the convenience of locating the permanent labourers in desirable proximity to their several occupations. Cottages, therefore, if judiciously situated quite enhance the value of a farm, to the extent of their fair annual value.

It is not intended in this paper to treat of the geological knowledge necessary to the proper practice of land valuing, but simply to elucidate correct principles therein. Consequently we now approach the consideration of those special circumstances which affect the value of land in particular localities, and raise it above its ordinary value to an extent only limited by the nature of the particular causes which operate upon it. This is what is properly called accommodation land. Land in the neighbourhood of a large town, desirable in small quantities to the inhabitants, for the acquirement of which great competition usually exists, partakes of this character; as does also land adjoining, but not belonging to a gentleman's residence, the renting of which will afford him pleasureable amusement, or the means of removing or preventing a nuisance; and many other cases, too numerous to mention, but which will at once suggest themselves to every man of business.

It will be obvious that the value of this description of land, depends upon circumstances wholly beyond the rules which regulate the worth of ordinary estates. And it will be equally manifest that no defined directions can be given for estimating this extra value, which can be alone arrived at by a full consideration of all the attendant circumstances.

Wood Lands occasionally perplex the valuation of an estate. If the tenant has the liberty of using the lands in his occupation as may be most conducive to his own interest, the value of mere coppice lands, by which I mean lands growing underwood, is manifestly in accordance with the agricultural character of the soil

and subsoil; and for this reason—a valuation should always represent the worth of an estate at the time it is made according to its natural capabilities under liberal and judicious treatment; therefore, it should be assumed, that whatever the mode of cultivation might be, it is such as has been found by experience to conduce most largely in conjunction with local circumstances to the advantage of the occupier.

On the other hand, if a valuer is exercising his profession for the purpose of estimating the rent of a farm upon which the tenant is bound to maintain all existing coppices and underwoods, either as preserves for game, or for other purposes over which he has no control, then, although the intrinsic value of the land remains the same, and should be so reported, still a greater rent cannot be charged the tenant than he can be enabled to pay out of the proceeds of the sale of the underwood, after defraying the whole of the expenses attending its cultivation and conversion, a proper interest for the use of his capital, and a fair remuneration to himself for his superintendence; and if the worth of the underwood when converted is not sufficient to meet these demands, then a sufficient sum must be deducted from the rent of the remaining lands to make up the deficiency, as it is manifestly in strict accordance with justice and equity that the landlord should alone suffer from a cause which he only is instrumental in perpetuating.

Wood lands, properly speaking, that is to say, lands growing timber trees, can only be estimated by the value of the timber they are capable of producing after a certain number of years' growth. A very small annual value sometimes attaches to wood lands offering pasture to cattle, but no general rule can be laid down for its computation.

Before I conclude this portion of my subject, it will be proper to observe, with reference to the *cost of labour* upon a farm, that the interest of an agricultural peasant in the land he cultivates must always be such as will afford him a maintenance, to whatever fluctuations the landlord's and tenant's interests therein may be nevertheless subjected. Both the proprietor and the occupier may be possessed of means that will enable them to speculate upon the future prospects of their respective positions, and to agree upon some arrangement that may exist between them throughout the continuance of a long lease; but the labourer of necessity can become no party to such a contract. The daily wants of himself and family are the same continually, partaking only of a pecuniary character, inasmuch as his requirements consist of a sufficiency of the necessities of life to enable him to conduct and carry on his humble avoca-

tions with comfort to himself and satisfaction to those for whose advantage he is toiling, and who are in consequence equally interested in his prosperity.

Therefore, in considering the cost of labour, the rate of wages is a primary consideration, and no method seems better calculated to ensure the proper fulfilment of this desideratum, than the method of valuing I have endeavoured to explain, that takes for its basis an estimate of all the items in bushels of wheat, inasmuch as it affords to the labourer a uniform amount of bread-stuff for the sustenance of his family irrespective of fluctuations in price.

The Purchase Value of Estates.

Having arrived at the annual rent which land is fairly worth to a tenant, if we deduct the amount of landlord's out-goings and burthens to which it is subject, we obtain a clear income or net annuity in perpetuity to the possessor, the value of which in fee simple it is very easy to determine. It is customary to assume that freehold land is worth 30 years' purchase, but its exact value must of course depend upon the worth of other good securities at the same time. The following Tables will be found to contain all the information and assistance that can be required in reducing the net annual rental of an estate to its purchase value, whether it be freehold (equal to an annuity in perpetuity,) or leasehold of any denomination.

Table 1. Showing the NUMBER OF YEARS' PURCHASE upon the Net Rental required to return a given Rate of Interest.

Rate of Interest per Centum per Annum.	Number of Years' Purchase on the net Rental.
2	**50**
2¼	44.4
2½	40
2¾	36.3
3	**33.3**
3¼	30.7
3½	28.5
3¾	26.6
4	**25**
4¼	23.25
4½	22.2
4¾	21
5	**20**
5¼	19
5½	18.1
5¾	17.4
6	**16.6**
6¼	16
6½	15.4
6¾	14.8
7	**14.2**
7¼	13.7
7½	13.3
7¾	12.9
8	**12.5**

EXAMPLE. 1. An Estate required to pay 4½ per cent. interest must be purchased at 22.2 years.

EXAMPLE 2. An Estate purchased at 30.7 years' purchase pays 3¼ per cent interest.

Table 2. Showing the PRESENT WORTH of an ESTATE, LEASE, or ANNUITY, for any number of years certain and in perpetuity, at the several rates of Interest which a purchaser may thereby make of his money.

Note.—The rate of Interest shown in this Table is that which a purchaser may make of his money, and get back his Capital, provided he can re-invest his money at the same rate of Interest.

Years Purchase at				Term of Years.	Years Purchase at			
3 per cent.	**4** per cent.	**5** per cent.	**6** per cent.		**7** per cent.	**8** per cent.	**9** per cent.	**10** per cent.
.5	.5	.5	.5	½	.5	.5	.5	.5
1.	1.	1.	.9	1	.9	.9	.9	.9
1.4	1.4	1.4	1.4	1½	1.4	1.4	1.3	1.3
1.9	**1.9**	**1.9**	**1.8**	**2**	**1.8**	**1.8**	**1.8**	**1.7**
2.4	2.3	2.3	2.3	2½	2.2	2.2	2.2	2.1
2.8	2.8	2.7	2.7	3	2.6	2.6	2.5	2.5
3.3	3.2	3.1	3.1	3½	3.	3.	2.9	2.8
3.7	**3.6**	**3.5**	**3.5**	**4**	**3.4**	**3.3**	**3.2**	**3.2**
4.2	4.	3.9	3.8	4½	3.7	3.7	3.6	3.5
4.6	4.5	4.3	4.2	5	4.1	4.	3.9	3.8
5.	4.9	4.7	4.6	5½	4.4	4.3	4.2	4.1
5.4	**5.2**	**5.1**	**5.**	**6**	**4.8**	**4.6**	**4.5**	**4.4**
5.8	5.6	5.4	5.3	6½	5.1	4.9	4.8	4.6
6.2	6.	5.8	5.6	7	5.4	5.2	5.	4.9
6.6	6.4	6.1	5.9	7½	5.7	5.5	5.3	5.1
7.	**6.7**	**6.5**	**6.2**	**8**	**6.**	**5.7**	**5.5**	**5.3**
7.4	7.1	6.8	6.5	8½	6.2	6.	5.8	5.6
7.8	7.4	7.1	6.8	9	6.5	6.2	6.	5.8
8.2	7.8	7.4	7.1	9½	6.8	6.5	6.2	6.
8.5	**8.1**	**7.7**	**7.4**	**10**	**7.**	**6.7**	**6.4**	**6.1**
8.9	8.4	8.	7.6	10½	7.3	6.9	6.6	6.3
9.2	8.8	8.3	7.9	11	7.5	7.1	6.8	6.5
9.6	9.1	8.6	8.1	11½	7.7	7.3	7.	6.7
9.9	**9.4**	**8.9**	**8.4**	**12**	**7.9**	**7.5**	**7.2**	**6.8**
10.3	9.7	9.1	8.6	12½	8.2	7.7	7.3	7.
10.6	10.	9.4	8.9	13	8.4	7.9	7.5	7.1
11.	10.3	9.6	9.1	13½	8.6	8.1	7.6	7.2
11.3	**10.6**	**9.9**	**9.3**	**14**	**8.7**	**8.2**	**7.8**	**7.4**
11.6	10.8	10.1	9.5	14½	8.9	8.4	7.9	7.5
11.9	11.1	10.4	9.7	15	9.1	8.6	8.1	7.6
12.2	11.4	10.6	9.9	15½	9.3	8.7	8.2	7.7
12.6	**11.7**	**10.8**	**10.1**	**16**	**9.4**	**8.9**	**8.3**	**7.8**
12.9	11.9	11.1	10.3	16½	9.6	9.	8.4	7.9
13.2	12.2	11.3	10.5	17	9.8	9.1	8.5	8.
13.5	12.4	11.5	10.7	17½	9.9	9.2	8.7	8.1
13.7	**12.7**	**11.7**	**10.8**	**18**	**10.1**	**9.4**	**8.8**	**8.2**

EXAMPLE. A Lease for seven years to make 5 per cent. is worth in present money 5.8 years' purchase.

If it is required to make 6 per cent. it will only be worth 5.6 years' purchase.

Again, a Lease for fourteen years that can be purchased for 8.2 years' purchase will pay 8 per cent. and get back the principal.

Table 2. Showing the PRESENT WORTH of an ESTATE, LEASE, or ANNUITY, for any number of years certain and in perpetuity, at the several rates of Interest which a purchaser may thereby make of his money.

Note.—The rate of Interest shown in this Table is that which a purchaser may make of his money, and get back his Capital, provided he can re-invest his money at the same rate of Interest.

Years Purchase at				Term of Years.	Years Purchase at			
3 per cent.	4 per cent.	5 per cent.	6 per cent.		7 per cent.	8 per cent.	9 per cent.	10 per cent.
14.	12.9	11.9	11.	18½	10.2	9.5	8.9	8.3
14.3	13.1	12.1	11.2	19	10.3	9.6	8.9	8.4
14.6	13.4	12.3	11.3	19½	10.5	9.7	9.	8.4
14.9	**13.6**	**12.5**	**11.5**	**20**	**10.6**	**9.8**	**9.1**	**8.5**
15.1	13.8	12.6	11.6	20½	10.7	9.9	9.2	8.6
15.4	14.	12.8	11.8	21	10.8	10.	9.3	8.6
15.7	14.2	13.	11.9	21½	10.9	10.1	9.4	8.7
15.9	**14.5**	**13.2**	**12.**	**22**	**11.1**	**10.2**	**9.4**	**8.8**
16.2	14.7	13.3	12.2	22½	11.2	10.3	9.5	8.8
16.4	14.9	13.5	12.3	23	11.3	10.4	9.6	8.9
16.7	15.1	13.6	12.4	23½	11.4	10.5	9.6	8.9
16.9	**15.2**	**13.8**	**12.5**	**24**	**11.5**	**10.5**	**9.7**	**9.**
17.2	15.4	13.9	12.7	24½	11.6	10.6	9.8	9.
17.4	15.6	14.1	12.8	25	11.7	10.7	9.8	9.1
17.6	15.8	14.2	12.9	25½	11.7	10.7	9.9	9.1
17.9	**16.**	**14.4**	**13.**	**26**	**11.8**	**10.8**	**9.9**	**9.2**
18.1	16.2	14.5	13.1	26½	11.9	10.9	10.	9.2
18.3	16.3	14.6	13.2	27	12.	10.9	10.	9.2
18.5	16.5	14.8	13.3	27½	12.1	11.	10.1	9.3
18.8	**16.7**	**14.9**	**13.4**	**28**	**12.1**	**11.1**	**10.1**	**9.3**
19.	16.8	15.	13.5	28½	12.2	11.1	10.2	9.3
19.2	17.	15.1	13.6	29	12.3	11.2	10.2	9.4
19.4	17.1	15.3	13.7	29½	12.3	11.2	10.2	9.4
19.6	**17.3**	**15.4**	**13.8**	**30**	**12.4**	**11.3**	**10.3**	**9.4**
19.8	17.4	15.5	13.8	30½	12.5	11.3	10.3	9.5
20.	17.6	15.6	13.9	31	12.5	11.3	10.3	9.5
20.2	17.7	15.7	14.	31½	12.6	11.4	10.4	9.5
20.4	**17.9**	**15.8**	**14.1**	**32**	**12.6**	**11.4**	**10.4**	**9.5**
20.6	18.	15.9	14.2	32½	12.7	11.5	10.4	9.5
20.8	18.1	16.	14.2	33	12.8	11.5	10.5	9.6
20.9	18.3	16.1	14.3	33½	12.8	11.6	10.5	9.6
21.1	**18.4**	**16.2**	**14.4**	**34**	**12.9**	**11.6**	**10.5**	**9.6**
21.3	18.5	16.3	14.4	34½	12.9	11.6	10.5	9.6
21.5	18.7	16.4	14.5	35	12.9	11.7	10.6	9.6
21.7	18.8	16.5	14.6	35½	13.	11.7	10.6	9.7
21.8	**18.9**	**16.5**	**14.6**	**36**	**13.**	**11.7**	**10.6**	**9.7**

EXAMPLE.—A Lease for 21 years to pay 4 per cent and get back the principal is worth in present money 14 years' purchase.

To pay 5 per cent. the same Lease is worth 12.8 years' purchase.

To pay 7 per cent. 10.8 years' purchase, &c.

Table 2. Showing the PRESENT WORTH of an ESTATE, LEASE, or ANNUITY, for any number of years certain and in perpetuity, at the several rates of Interest which a purchaser may thereby make of his money.

Note.—The rate of Interest shown in this Table is that which a purchaser may make of his money, and get back his Capital, provided he can re-invest at the same rate.

Years Purchase at				Term of Years.	Years Purchase at			
3 per cent.	**4** per cent.	**5** per cent.	**6** per cent.		**7** per cent.	**8** per cent.	**9** per cent.	**10** per cent.
22.2	19.1	16.7	14.7	37	13.1	11.8	10.7	9.7
22.5	19.4	16.9	14.8	38	13.2	11.8	10.7	9.7
22.8	19.6	17.	14.9	39	13.3	11.9	10.7	9.8
23.1	**19.8**	**17.2**	**15.**	**40**	**13.3**	**11.9**	**10.8**	**9.8**
23.4	20.	17.3	15.1	41	13.4	12.	10.8	9.8
23.7	20.2	17.4	15.2	42	13.5	12.	10.8	9.8
24.	20.4	17.5	15.3	43	13.5	12.	10.8	9.8
24.3	**20.5**	**17.7**	**15.4**	**44**	**13.6**	**12.1**	**10.9**	**9.8**
24.5	20.7	17.8	15.5	45	13.6	12.1	10.9	9.9
24.8	20.9	17.9	15.5	46	13.6	12.1	10.9	9.9
25.	21.	18.	15.6	47	13.7	12.2	10.9	9.9
25.3	**21.2**	**18.1**	**15.6**	**48**	**13.7**	**12.2**	**10.9**	**9.9**
25.5	21.3	18.2	15.7	49	13.8	12.2	10.9	9.9
25.7	21.5	18.3	15.8	50	13.8	12.2	11.	9.9
26.	21.6	18.3	15.8	51	13.8	12.3	11.	9.9
26.2	**21.7**	**18.4**	**15.9**	**52**	**13.9**	**12.3**	**11.**	**9.9**
26.4	21.9	18.5	15.9	53	13.9	12.3	11.	9.9
26.6	22.	18.6	15.9	54	13.9	12.3	11.	9.9
26.8	22.1	18.6	16.	55	13.9	12.3	11.	9.9
27.	**22.2**	**18.7**	**16.**	**56**	**14.**	**12.3**	**11.**	**10.**
27.2	22.3	18.8	16.	57	14.	12.3	11.	10.
27.3	22.4	18.8	16.1	58	14.	12.4	11.	10.
27.5	22.5	18.9	16.1	59	14.	12.4	11.	10.
27.7	**22.6**	**18.9**	**16.1**	**60**	**14.**	**12.4**	**11.**	**10.**
27.8	22.7	19.1	16.2	61	14.	12.4	11.	10.
28.	22.8	19.	16.2	62	14.1	12.4	11.1	10.
28.1	22.9	19.1	16.2	63	14.1	12.4	11.1	10.
28.3	**23.**	**19.1**	**16.3**	**64**	**14.1**	**12.4**	**11.1**	**10.**
28.5	23.	19.2	16.3	65	14.1	12.4	11.1	10.
28.6	23.1	19.2	16.3	66	14.1	12.4	11.1	10.
28.7	23.2	19.2	16.3	67	14.1	12.4	11.1	10.
28.9	**23.3**	**19.3**	**16.3**	**68**	**14.1**	**12.4**	**11.1**	**10.**
29.	23.3	19.3	16.4	69	14.1	12.4	11.1	10
29.1	23.4	19.3	16.4	70	14.2	12.4	11.1	10
29.2	23.4	19.4	16.4	71	14.2	12.4	11.1	10
29.3	**23.5**	**19.4**	**16.4**	**72**	**14.2**	**12.4**	**11.1**	**10.**

EXAMPLE.—An Estate held for sixty years to get back principal and interest is worth in present money:

If 3 per Cent. Interest is required	. . .	27.7	years' purchase
4 „ „	.	22.6	„
5 „ „	. . .	18.9	„
„ „	. . .	16.1	„

Table 2. Showing the PRESENT WORTH of an ESTATE, LEASE, or ANNUITY, for any number of years certain and in perpetuity, at the several rates of Interest which a purchaser may thereby make of his money.

Note.—The rate of Interest shown in this Table is that which a purchaser may make of his money, and get back his Capital, provided he can re-invest at the same rate.

Years Purchase at				Term of Years.	Years Purchase at			
3 per cent.	4 per cent.	5 per cent.	6 per cent.		7 per cent.	8 per cent.	9 per cent.	10 per cent.
29.5	23.6	19.4	16.4	73	14.2	12.4	11.1	10.
29.6	23.6	19.5	16.4	74	14.2	12 5	11.1	10.
29.7	23.7	19.5	16.4	75	14.2	12.5	11.1	10.
29.8	**23.7**	**19.5**	**16.5**	**76**	**14.2**	**12.5**	**11.1**	**10.**
29.9	23.8	19.5	16.5	77	14.2	12.5	11.1	10.
30.	23.8	19.5	16.5	78	14.2	12.5	11.1	10.
30.1	23.9	19.6	16.5	79	14.2	12.5	11.1	10.
30.2	**23.9**	**19.6**	**16.5**	**80**	**14.2**	**12.5**	**11.1**	**10.**
30.3	24.	19.6	16.5	81	14.2	12.5	11.1	10.
30.4	24.	19.6	16.5	82	14.2	12.5	11.1	10.
30.5	24.	19.6	16.5	83	14.2	12.5	11.1	10.
30.6	**24.1**	**19.7**	**16.5**	**84**	**14.2**	**12.5**	**11.1**	**10.**
30.6	24.1	19.7	16.5	85	14.2	12.5	11.1	10.
30.7	24.1	19.7	16.5	86	14.2	12.5	11.1	10.
30.8	24.2	19.7	16.6	87	14.2	12.5	11.1	10.
30.9	**24.2**	**19.7**	**16.6**	**88**	**14.2**	**12.5**	**11.1**	**10.**
30.9	24.2	19.7	16.6	89	14.2	12.5	11.1	10.
31.	24.3	19.7	16.6	90	14.2	12.5	11.1	10.
31.1	24.3	19.8	16.6	91	14.2	12.5	11.1	10.
31.1	**24.3**	**19.8**	**16.6**	**92**	**14.3**	**12.5**	**11.1**	**10.**
31.2	24.3	19.8	16.6	93	14.3	12.5	11.1	10.
31.3	24.4	19.8	16.6	94	14.3	12.5	11.1	10.
31.3	24.4	19.8	16.6	95	14.3	12.5	11.1	10.
31.4	**24.4**	**19.8**	**16.6**	**96**	**14.3**	**12.5**	**11.1**	**10.**
31.4	24.4	19.8	16.6	97	14.3	12.5	11.1	10.
31.5	24.5	19.8	16.6	98	14.3	12.5	11.1	10.
31.5	24.5	19.8	16.6	99	14.3	12.5	11.1	10.
31.6	**24.5**	**19.8**	**16.6**	**100**	**14.3**	**12.5**	11.1	10.
33.3	**25.**	**20.**	**16.7**	Perpetuity	**14.3**	**12.5**	**11.1**	**10.**

EXAMPLE.—A Lease for ninety-nine years to pay 7 per cent., and get back the principal, is worth 14.3 years' purchase.

The Fee Simple of a Freehold Estate to pay 5 per cent. is worth 20 years' purchase or to pay 3 per cent., 33.3 years' purchase.

Table 3. PRESENT WORTH of Property held on a single life, as of a person in possession of a LIVING or BENEFICE, or the holder of a LEASE, ESTATE, or ANNUITY, according to the *Northampton* Table of Mortality*.

Note.—The rate of Interest shown in this Table is that which a purchaser can make of his money, and get back his Capital, provided he can re-invest at the same rate.

Years Purchase at			Age of the Life.	Years Purchase at		
3 per cent.	**4** per cent.	**5** per cent.		**6** per cent.	**7** per cent.	**8** per cent.
16.	13.5	11.6	1	10.1	9.	8.
18.6	15.6	13.4	2	11.7	10.4	9.3
19.6	16.5	14.1	3	12.3	10.9	9.8
20.2	**17.0**	**14.6**	**4**	**12.8**	**11.3**	**10.1**
20.5	17.2	14.8	5	13.	11.5	10.3
20.7	17.5	15.	6	13.2	11.7	10.5
20.9	17.6	15.2	7	13.3	11.8	10.6
20.9	**17.7**	**15.2**	**8**	**13.3**	**11.8**	**10.6**
20.8	17.6	15.2	9	13.3	11.8	10.6
20.7	17.5	15.1	10	13.3	11.8	10.6
20.5	17.4	15.	11	13.2	11.8	10.6
20.3	**17.3**	**14.9**	**12**	**13.1**	**11.7**	**10.5**
20.1	17.1	14.8	13	13.	11.6	10.5
19.9	16.9	14.7	14	13.	11.5	10.4
19.7	16.8	14.6	15	12.9	11.5	10.3
19.4	**16.6**	**14.5**	**16**	**12.8**	**11.4**	**10.3**
19.2	16.5	14.3	17	12.7	11.3	10.2
19.	16.3	14.2	18	12.6	11.2	10.1
18.8	16.2	14.1	19	12.5	11.2	10.1
18.6	**16.**	**14.**	**20**	**12.4**	**11.1**	**10.**
18.5	15.9	13.9	21	12.3	11.	10.
18.3	15.8	13.8	22	12.3	11.	9.9
18.1	15.7	13.7	23	12.2	10.9	9.9
18.	**15.6**	**13.7**	**24**	**12.1**	**10.9**	**9.9**
17.8	15.4	13.6	25	12.1	10.8	9.8
17.6	15.3	13.5	26	12.	10.8	9.8
17.5	15.2	13.4	27	11.9	10.7	9.7
17.3	**15.1**	**13.3**	**28**	**11.8**	**10.7**	**9.7**
17.1	14.9	13.2	29	11.8	10.6	9.6
16.9	14.8	13.1	30	11.7	10.5	9.6
16.7	14.6	13.	31	11.6	10.5	9.5
16.5	**14.5**	**12.9**	**32**	**11.5**	**10.4**	**9.5**
16.3	14.3	12.7	33	11.4	10.3	9.4
16.1	14.2	12.6	34	11.3	10.3	9.4
15.9	14.	12.5	35	11.2	10.2	9.3
15.7	**13.9**	**12.4**	**36**	**11.1**	**10.1**	**9.2**

EXAMPLE. An Estate, Annuity, or a Lease, held on a single life aged 29, to make 4 per cent. and to get back the Principal, is worth 14.9 years' purchase.

To make 5 per cent. it would be 13.2 years' Purchase

* The Carlisle Tables of Mortality are the most favorable to the seller of Lifehold Estates, and the London the most favorable to the purchaser. The Northampton Tables as the mean may perhaps be considered the most equitable.

Table 3 *continued.* PRESENT WORTH of PROPERTY held on a single life, as of a person in possession of a LIVING or BENEFICE, or the holder of a LEASE, ESTATE, or ANNUITY, according to the *Northampton Table of Mortality.*

Note.—The rate of Interest shown in this Table is that which a purchaser may make of his money, and get back the Principal, provided he can re-invest at the same rate.

Years Purchase at			Age of the Life.	Years Purchase at		
3 per cent.	4 per cent.	5 per cent.		6 per cent.	7 per cent.	8 per cent.
15.5	13.7	12.2	37	11.	10.	9.2
15.3	13.5	12.1	38	10.9	9.9	9.1
15.1	13.4	12.	39	10.8	9.8	9.
14.8	**13.2**	**11.8**	**40**	**10.7**	**9.8**	**8.9**
14.6	13.	11.7	41	10.6	9.7	8.9
14.4	12.8	11.6	42	10.5	9.6	8.8
14.2	12.7	11.4	43	10.4	9.5	8.7
13.9	**12.5**	**11.3**	**44**	**10.2**	**9.4**	**8.6**
13.7	12.3	11.1	45	10.1	9.3	8.5
13.4	12.1	10.9	46	10.	9.2	8.4
13.2	11.9	10.8	47	9.8	9.	8.3
13.	**11.7**	**10.6**	**48**	**9.7**	**8.9**	**8.2**
12.7	11.5	10.4	49	9.6	8.8	8.1
12.4	11.3	10.3	50	9.4	8.7	8.
12.2	11.1	10.1	51	9.3	8.6	7.9
11.9	**10.8**	**9.9**	**52**	**9.1**	**8.4**	**7.8**
11.7	10.6	9.7	53	9.	8.3	7.7
11.4	10.4	9.6	54	8.8	8.2	7.6
10.9	10.	9.2	56	8.5	7.9	7.4
10.3	**9.5**	**8.8**	**58**	**8.2**	**7.6**	**7.1**
9.8	9.	8.4	60	7.8	7.3	6.9
9.2	8.5	8.	62	7.4	7.	6.6
8.6	8.	7.5	64	7.1	6.6	6.3
8.	**7.5**	**7.**	**66**	**6.6**	**6.3**	**5.9**
7.4	6.9	6.5	68	6.2	5.9	5.6
6.7	6.4	6.	70	5.7	5.4	5.2
6.1	5.8	5.5	72	5.2	5.	4.8
5.5	**5.2**	**5.**	**74**	**4.8**	**4.6**	**4.4**
4.9	4.7	4.5	76	4.3	4.2	4.0
4.4	4.2	4.	78	3.9	3.7	3.6
3.8	3.6	3.5	80	3.4	3.3	3.2
3.2	**3.1**	**3.**	**82**	**2.9**	**2.8**	**2.8**
2.8	2.7	2.6	84	2.6	2.5	2.4
2.5	2.4	2.3	86	2.3	2.2	2.2
2.2	2.1	2.1	88	2.	2.	1.9
1.8	**1.8**	**1.7**	**90**	**1.7**	**1.7**	**1.6**

EXAMPLE. An Estate, Annuity, or a Lease, held on a single life aged 50, to make 3 per cent. and to get back the Principal, is worth 12.4, years' purchase.

To make 4 per cent. it would be 11.3 years' purchase.

The next presentation to a living being vacant is to be considered as a Lifehold at 5 per cent. All annual charges, of whatever kind (including that of a Curate,) must be deducted from the gross income to find the net annual income.

Table 4. PRESENT WORTH of Property held on a single life, as of a person in possession of a LIVING or BENEFICE, or the holder of a LEASE, ESTATE, or ANNUITY, according to the *Carlisle Table of Mortality*.

Note.—The rate of Interest shown in this Table is that which a Purchaser may make of his money, and get back his Principal, provided he can re-invest at the same rate.

Years Purchase at			Age of the Life.	Years Purchase at		
3 per cent.	**4** per cent.	**5** per cent.		**6** per cent.	**7** per cent.	**8** per cent.
20.1	16.6	14.	1	12.1	10.6	9.4
21.5	17.7	15.	2	12.9	11.3	10.1
22.7	18.7	15.8	3	13.7	12.	10.7
23.3	**19.2**	**16.3**	**4**	**14.**	**12.3**	**11.**
23.7	19.6	16.6	5	14.3	12.6	11.2
23.8	19.7	16.7	6	14.5	12.7	11.3
23.9	19.8	16.8	7	14.5	12.8	11.4
23.8	**19.8**	**16.8**	**8**	**14.5**	**12.8**	**11.4**
23.7	19.7	16.7	9	14.5	12.8	11.4
23.5	19.6	16.7	10	14.4	12.7	11.3
23.3	19.5	16.6	11	14.4	12.7	11.3
23.1	**19.3**	**16.5**	**12**	**14.3**	**12.6**	**11.3**
23.	19.2	16.4	13	14.3	12.6	11.2
22.8	19.1	16.3	14	14.2	12.5	11.2
22.6	19.	16.2	15	14.1	12.5	11.1
22.4	**18.8**	**16.1**	**16**	**14.1**	**12.4**	**11.1**
22.2	18.7	16.1	17	14.	12.4	11.1
22.1	18.6	16.	18	14.	12.3	11.1
21.9	18.5	15.9	19	13.9	12.3	11.
21.7	**18.4**	**15.8**	**20**	**13.8**	**12.3**	**11.**
21.5	18.2	15.7	21	13.8	12.2	10.9
21.3	18.1	15.6	22	13.7	12.2	10.9
21.1	18.	15.5	23	13.6	12.1	10.9
20.9	**17.8**	**15.4**	**24**	**13.5**	**12.**	**10.8**
20.7	17.6	15.3	25	13.5	12.	10.8
20.4	17.5	15.2	26	13.4	11.9	10.7
20.2	17.3	15.1	27	13.3	11.8	10.7
20.	**17.2**	**14.9**	**28**	**13.2**	**11.8**	**10.6**
19.8	17.	14.8	29	13.1	11.7	10.5
19.6	16.9	14.7	30	13.	11.6	10.5
19.3	16.7	14.6	31	12.9	11.6	10.5
19.1	**16.6**	**14.5**	**32**	**12.9**	**11.5**	**10.4**
18.9	16.4	14.4	33	12.8	11.4	10.4
18.7	16.2	14.3	34	12.7	11.4	10.3
18.4	16.	14.1	35	12.6	11.3	10.2
18.2	**15.9**	**14.**	**36**	**12.5**	**11.2**	**10.2**

EXAMPLE. An Estate, Annuity, or a Lease held on a single life aged 29, to make 4 per cent. and get back the Principal, is worth 17 years' purchase.
To make 5 per cent., 14.8 years' purchase.

Table 4 *continued.* PRESENT WORTH of Property held on a single life, as of a person in possession of a LIVING or BENEFICE, or the holder of a LEASE, ESTATE, or ANNUITY, according to the *Carlisle Table of Mortality.*

Note.—The rate of Interest shown in this Table is that which a Purchaser can make of his money, and get back his Capital, provided he can re-invest at the same rate.

Years Purchase at			Age of the Life.	Years Purchase at		
3 per cent.	4 per cent.	5 per cent.		6 per cent.	7 per cent.	8 per cent.
17.9	15.7	13.8	37	12.4	11.1	10.1
17.7	15.5	13.7	38	12.2	11.	10.
17.4	15.3	13.5	39	12.1	10.9	9.9
17.1	**15.1**	**13.4**	**40**	**12.**	**10.8**	**9.9**
16.9	14.9	13.2	41	11.9	10.8	9.8
16.6	14.7	13.1	42	11.8	10.7	9.7
16.4	14.5	13.	43	11.7	10.6	9.7
16.1	**14.3**	**12.8**	**44**	**11.6**	**10.5**	**9.6**
15.9	14.1	12.6	45	11.4	10.4	9.5
15.6	13.9	12.5	46	11.3	10.3	9.4
15.3	13.7	12.3	47	11.2	10.2	9.3
15.	**13.4**	**12.1**	**48**	**11.**	**10.1**	**9.2**
14.7	13.2	11.9	49	10.8	9.9	9.1
14.3	12.9	11.7	50	10.6	9.7	9.
13.9	12.6	11.4	51	10.4	9.6	8.8
13.6	**12.3**	**11.2**	**52**	**10.2**	**9.4**	**8.7**
13.2	11.9	10.9	53	10.	9.2	8.5
12.8	11.6	10.6	54	9.8	9.	8.4
12.	11.	10.1	56	9.3	8.6	8.
11.2	**10.3**	**9.5**	**58**	**8.8**	**8.2**	**7.6**
10.5	9.7	8.9	60	8.3	7.7	7.2
9.9	9.1	8.5	62	7.9	7.4	6.9
9.2	8.6	8.	64	7.5	7.	6.6
8.6	**8.**	**7.5**	**66**	**7.**	**6.6**	**6.3**
7.9	7.4	6.9	68	6.5	6.2	5.9
7.1	6.7	6.3	70	6.	5.7	5.4
6.4	6.	5.7	72	5.4	5.2	4.9
5.8	**5.5**	**5.2**	**74**	**4.9**	**4.7**	**4.5**
5.3	5.	4.8	76	4.6	4.4	4.2
4.8	4.6	4.4	78	4.2	4.1	3.9
4.4	4.2	4.	80	3.9	3.7	3.6
3.9	**3.7**	**3.6**	**82**	**3.5**	**3.4**	**3.2**
3.5	3.3	3.2	84	3.1	3.	2.9
3.	2.9	2.8	86	2.7	2.7	2.6
2.8	2.7	2.6	88	2.5	2.4	2.4
2.5	**2.4**	**2.3**	**90**	**2.3**	**2.2**	**2.1**

EXAMPLE. An Estate, Annuity, or a Lease held on a single life aged 50, to make 3 per cent. and get back the Principal, is worth 14.3 years' purchase.

To make 4 per cent., 12.9 years' purchase.

Note.—It will be observed that the Carlisle Table of Mortality is more favorable than the Northampton, and may be used accordingly on healthy lives.

Table 5. PRESENT WORTH of an ESTATE, ANNUITY, or a LEASE held on Two Joint Lives, according to the *Northampton Table of Mortality.*

Note.—The Rate of Interest shown in this Table is that which a purchaser may make of his money, and get back his Principal, provided he can re-invest at the same rate.

Years Purchase at		Ages.	Years Purchase at	
3 per cent.	**4** per cent.		**5** per cent.	**6** per cent.
16.34	**14.28**	**10 — 10**	**12.66**	**11.34**
15.15	13.36	10 — 20	11.91	10.72
14.15	12.59	10 — 30	11.30	10.24
12.79	11.51	10 — 40	10.44	9.54
11.04	10.08	10 — 50	9.26	8.55
8.95	8.31	10 — 60	7.75	7.25
6.35	6.01	10 — 70	5.70	5.42
3.65	3.52	10 — 80	3.39	3.28
14.13	**12.53**	**20 — 20**	**11.23**	**10.16**
13.29	11.87	20 — 30	10.71	9.73
12.10	10.92	20 — 40	9.94	9.10
20.52	9.63	20 — 50	8.86	8.19
8.60	8.00	20 — 60	7.46	6.99
6.15	5.83	20 — 70	5.53	5.26
3.57	3.44	20 — 80	3.32	3.21
12.59	**11.31**	**30 — 30**	**10.25**	**9.36**
11.57	10.49	30 — 40	9.58	8.79
10.16	9.32	30 — 50	8.60	7.97
8.38	7.80	30 — 60	7.29	6.84
6.04	5.73	30 — 70	5.44	5.18
3.53	3.41	30 — 80	3.29	3.18
10.76	**9.82**	**40 — 40**	**9.02**	**8.32**
9.59	8.83	40 — 50	8.18	7.60
8.02	7.49	40 — 60	7.01	6.59
5.87	5.57	40 — 70	5.30	5.05
3.47	3.35	40 — 80	3.24	3.13
8.71	**8.08**	**50 — 50**	**7.52**	**7.03**
7.46	6.99	50 — 60	6.57	6.19
5.58	5.30	50 — 70	5.05	4.82
3.36	3.25	50 — 80	3.14	3.04
6.61	**6.23**	**60 — 60**	**5.89**	**5.58**
5.14	4.90	60 — 70	4.68	4.48
3.20	3.09	60 — 80	2.99	2.90
4.26	**4.09**	**70 — 70**	**3.93**	**3.78**

EXAMPLE.—An Estate, Annuity, or a Lease held on Two Joint Lives, aged 40 and 50 years, which is to be determined on the death of either, to make 3 per cent. and get back the Principal, is worth 9.59 years' purchase. To make 4 per cent. it is worth 8.83 years' purchase.

Table 6. Showing the PRESENT VALUE of an ESTATE, ANNUITY, or a LEASE, held on the *longest of Two Lives*, calculated accordng to the *Northampton Table of Mortality*.

Note. The rate of interest shewn in this Table is that which a purchaser may make of his money, and get back his Capital, provided he can re-invest at the same rate.

Ages of the Lives.	Years Purchase at 3 p. cent.	4 p. cent.	5 p. cent.	6 p. cent.	Ages of the Lives.	Years Purchase at 3 p. cent.	4 p. cent.	5 p. cent.	6 p. cent.
5 — 5	25.3	20.9	17.7	15.3	25 — 65	18.7	16.3	14.3	12.7
5 — 15	24.7	20.6	17.5	15.1	25 — 75	18.2	15.8	13.9	12.4
5 — 25	24.0	20.0	17.1	14.9	**30 — 30**	**20.3**	**18.2**	**15.9**	**14.0**
5 — 35	23.3	19.6	16.8	14.6	30 — 40	20.2	17.5	15.3	13.6
5 — 45	22.6	19.0	16.4	14.3	30 — 50	19.2	16.7	14.7	13.1
5 — 55	21.9	18.5	16.0	13.9	30 — 60	18.3	16.0	14.2	12.7
5 — 65	21.3	18.0	15.6	13.6	30 — 70	17.6	15.4	13.7	12.2
5 — 75	20.9	17.7	15.2	13.3	30 — 80	17.2	15.0	13.3	11.9
10 — 10	**25.0**	**20.8**	**17.6**	**15·2**	**35 — 35**	**20.1**	**17.5**	**15.3**	**13.6**
10 — 20	24.1	20.2	17.2	15.0	35 — 45	19.0	16.6	14.7	13.1
10 — 30	23.4	19.7	16.9	14.7	35 — 55	18.0	15.8	14.0	12.5
10 — 40	22.7	19.2	16.5	14.5	35 — 65	17.1	15.0	13.4	12.0
10 — 50	22.1	18.7	16.1	14.2	35 — 75	16.4	14.5	12.9	11.6
10 — 60	21.5	18.2	15.8	13.9	**40 — 40**	**18.9**	**16.6**	**14.7**	**13.1**
10 — 70	21.0	17.9	15.5	13.4	40 — 50	17.7	15.6	13.9	12.5
10 — 80	20.8	17.6	15.3	13.4	40 — 60	16.6	14.7	13.2	11.9
15 — 15	**24.0**	**20.2**	**17.2**	**14.9**	40 — 70	15.7	14.0	12.6	11.4
15 — 25	23.2	19.6	16.8	14.7	40 — 80	15.2	13.5	12.1	11.0
15 — 35	22.4	19.0	16.4	14.4	**45 — 45**	**17.6**	**15.6**	**13.9**	**12.5**
15 — 45	21.7	18.5	16.0	14.0	45 — 55	16.3	14.5	13.1	11.8
15 — 55	21.0	17.9	15.6	13.7	45 — 65	15.1	13.6	12.3	11.3
15 — 65	20.4	17.4	15.2	13.3	45 — 75	14.3	12.9	11.6	10.6
15 — 75	19.9	17.1	14.8	13.1	**50 — 50**	**16.2**	**14.4**	**13.0**	**11.8**
20 — 20	**23.1**	**19.5**	**16.8**	**14.6**	50 — 60	14.8	13.3	12.1	11.0
20 — 30	22.3	18.9	16.4	14.3	50 — 70	13.6	12.3	11.2	10.3
20 — 40	21.4	18.3	15.9	14.0	50 — 80	12.9	11.7	10.6	9.8
20 — 50	20.6	17.7	15.4	13.6	**55 — 55**	**14.6**	**13.2**	**12.0**	**11.0**
20 — 60	19.8	17.1	14.9	13.2	55 — 65	13.1	12.0	11.0	10.1
20 — 70	19.2	16.6	14.5	12.9	55 — 75	12.0	11.0	10.1	9.3
20 — 80	18.8	16.2	14.2	12.6	**60 — 60**	**12.9**	**11.9**	**10.9**	**10.1**
25 — 25	**22.2**	**18.9**	**16.4**	**14.4**	60 — 70	11.4	10.5	9.7	9.1
25 — 35	21.3	18.3	15.9	14.0	60 — 80	10.4	9.6	8.9	8.3
25 — 45	20.3	17.6	15.4	13.6	**65 — 75**	**9.5**	**8.9**	**8.4**	**7.8**
25 — 55	19.5	16.9	14.8	13.1	70 — 70	9.2	8.6	8.1	7.6

EXAMPLE. An Estate, Annuity, or a Lease, to be determined at the death of the longest of Two Lives, whose ages are 25 and 35 years; to make 3 per cent. and get back the Principal, is worth 21.3 years' purchase; to make 4 per cent. it is worth 18.3 years' purchase.

Table 7. PRESENT WORTH of an ESTATE, ANNUITY, or a LEASE, held on the *longest of Three Lives*, according to the *Northampton Table of Mortality*.

Note.—The rate of Interest shewn in this Table is that which a purchaser may make of his money, and get back the Principal, provided he can re-invest at the same rate.

Ages of the Lives.	Years Purchase at 3 p. cent.	4 p. cent.	5 p. cent.	6 p. cent.	Ages of the Lives.	Years Purchase at 3 p. cent.	4 p. cent.	5 p. cent.	6 p. cent.
10 10 10	**26.6**	**21.9**	**18.3**	**15.7**	**10 40 40**	**23.7**	**19.9**	**17.1**	**14.9**
10 10 20	26.2	21.7	18.3	15.7	10 40 50	23.1	19.6	16.8	14.7
10 10 30	25.8	21.4	18.0	15.6	10 40 60	22.9	19.4	16.7	14.6
10 10 40	25.4	21.1	17.9	15.5	10 40 70	22.7	19.1	16.5	14.4
10 10 50	25.3	20.8	17.7	15.3	**10 45 45**	**23.3**	**19.5**	**16.8**	**14.7**
10 10 60	25.0	20.8	17.6	15.2	10 45 55	22.6	19.2	16.6	14.6
10 10 70	25.0	20.8	17.6	15.2	10 45 65	22.5	19.0	16.4	14.5
10 20 20	**25.7**	**21.3**	**18.1**	**15.5**	10 45 75	22.2	18.8	16.2	14.2
10 20 30	25.1	21.0	17.8	15.4	**10 50 50**	**22.6**	**19.2**	**16.6**	**14.5**
10 20 40	24.6	20.6	17.6	15.2	10 50 60	22.2	18.9	16.3	14.3
10 20 50	24.5	20.4	17.4	15.1	10 50 70	22.0	18.7	16.1	14.1
10 20 60	24.3	20.3	17.4	15.1	**10 55 55**	**22.3**	**19.0**	**16.4**	**14.2**
10 20 70	24.1	20.1	17.2	14.9	10 55 65	21.8	18.5	16.0	14.1
10 25 25	**25.1**	**20.9**	**17.8**	**15.5**	10 55 75	21.8	18.5	16.0	14.1
10 25 35	24.6	20.6	17.6	15.2	**10 60 60**	**22.0**	**18.7**	**15.9**	**14.0**
10 25 45	24.4	20.5	17.4	15.1	10 60 70	21.6	18.4	15.9	14.0
10 25 55	24.1	20.3	17.2	14.9	**10 65 65**	**21.5**	**18.2**	**15.8**	**14.2**
10 25 65	23.9	20.1	17.2	14.9	10 65 75	21.2	18.0	15.6	13.7
10 25 75	23.7	19.8	17.0	14.7	10 70 70	21.3	18.1	15.7	13.8
10 30 30	**24.8**	**20.6**	**17.6**	**15.3**	**15 25 25**	**24.8**	**20.8**	**17.7**	**15.4**
10 30 40	24.3	20.3	17.4	15.1	15 25 35	24.2	20.3	17.4	15.2
10 30 50	23.8	20.0	17.2	15.0	15 25 45	23.9	20.2	17.2	15.0
10 30 60	23.6	19.8	17.0	14.8	15 25 55	23.6	19.9	17.1	14.8
10 30 70	23.5	19.7	16.9	14.8	15 25 65	23.4	19.7	16.9	14.7
10 35 35	**24.2**	**20.4**	**17.5**	**15.1**	15 25 75	23.1	19.5	16.7	14.6
10 35 45	23.8	19.9	17.1	14.9	**15 35 35**	**23.7**	**20.1**	**17.1**	**15.0**
10 35 55	23.3	19.6	16.9	14.7	15 35 45	23.3	19.7	16.9	14.8
10 35 65	23.1	19.5	16.8	14.6	15 35 55	22.7	19.3	16.6	14.6
10 35 75	23.0	19.4	16.7	14.6	15 35 65	22.5	19.1	16.5	14.5

EXAMPLE. An Estate, Annuity, or a Lease, to determine on the death of the longest of Three Lives, aged 10, 35, and 55 years, to pay 3 per cent. and get back the Principal, is worth 23.3 years' purchase. To make 4 per cent. it is worth 19.6 years' purchase.

Table 7 *continued.* PRESENT WORTH of an ESTATE, ANNUITY, or a LEASE, held on the *longest of Three Lives*, according to the *Northampton Table of Mortality.*

Note. The rate of interest shown in this Table is that which a purchaser may make of his money, and get back the Principal, provided he can re-invest at the same rate.

Ages of the Lives.	Years Purchase at 3 p.cent.	4 p.cent.	5 p.cent.	6 p.cent.	Ages of the Lives.	Years Purchase at 3 p.cent.	4 p.cent.	5 p.cent.	6 p.cent.
15 35 75	22.4	19.0	16.4	14.4	20 35 55	22.1	18.9	16.4	14.4
15 45 45	**22.7**	**19.1**	**16.5**	**14.6**	20 35 65	21.9	18.7	16.2	14.3
15 45 55	22.0	18.8	16.3	14.3	20 35 75	21.8	18.6	16.1	14.2
15 45 65	21.8	18.6	16.1	14.2	**20 40 40**	**22.8**	**19.3**	**16.7**	**14.6**
15 45 75	21.5	18.3	15.9	14.0	20 40 50	22.1	18.9	16.4	14.4
15 55 55	**21.6**	**18.5**	**16.1**	**14.0**	20 40 60	21.7	18.6	16.2	14.2
15 55 65	21.1	18.0	15.6	13.9	20 40 70	21.4	18.3	15.9	14.
15 55 75	21.0	18.0	15.6	13.8	**20 45 45**	**22.**	**18.7**	**16.3**	**14.5**
15 65 65	**20.8**	**17.8**	**15.5**	**13.9**	20 45 55	21.4	18.4	16.	14.2
15 65 75	20.3	17.4	15.1	13.4	20 45 65	21.1	18.1	15.8	14.1
20 20 20	**25.2**	**20.8**	**17.8**	**15.4**	20 45 75	20.8	17.9	15.5	13.8
20 20 30	24.5	20.6	17.6	15.2	**20 50 50**	**21.4**	**18.4**	**16.**	**14.1**
20 20 40	23.9	20.2	17.3	15.1	20 50 60	20.9	18.	15.7	13.9
20 20 50	23.7	19.8	17.1	14.9	20 50 70	20.6	17.7	15.4	13.6
20 20 60	23.4	19.7	17.0	14.8	**20 55 55**	**20.9**	**18.**	**15.6**	**13.8**
20 20 70	23.2	19.5	16.8	14.6	20 55 65	20.3	17.5	15.2	13.6
20 25 25	**24.4**	**20.6**	**17.6**	**15.3**	20 55 75	20.3	17.3	15.2	13.5
20 25 35	23.8	20.1	17.3	15.1	**20 60 60**	**20.5**	**17.7**	**15.2**	**13.5**
20 25 45	23.5	19.9	17.0	14.9	20 60 70	20.	17.3	15.1	13.4
20 25 55	23.1	19.6	16.9	14.7	**20 65 65**	**20.**	**17.2**	**15.1**	**13.6**
20 25 65	22.9	19.4	16.7	14.6	20 65 75	19.5	16.8	14.7	13.1
20 25 75	22.6	19.1	16.5	14.4	20 70 70	19.6	16.9	14.8	13.1
20 30 30	**24.4**	**20.1**	**17.3**	**15.1**	**30 30 30**	**23.3**	**19.6**	**17.**	**14.9**
20 30 40	23.8	19.7	17.0	14.9	30 30 40	22.6	19.2	16.6	14.6
20 30 50	22.8	19.4	16.8	14.7	30 30 50	21.9	18.8	16.4	14.4
20 30 60	22.5	19.1	16.5	14.5	30 30 60	21.5	18.5	16.1	14.2
20 30 70	22.4	19.0	16.5	14.4	30 30 70	21.4	18.4	16.	14.1
20 35 35	**23.3**	**19.8**	**16.9**	**14.8**	**30 35 35**	**22.5**	**19.3**	**16.6**	**14.7**
20 35 45	22.7	19.4	16.8	14.7	30 35 45	21.8	18.6	16.2	14.4

EXAMPLE. An Estate, Annuity, or a Lease, to determine on the death of the longest of Three Lives, aged 20, 25, and 55 years; to pay 3 per cent. and get back the Principal, is worth 23.1 years' purchase. To make 4 per cent. it is worth 19.6 years' purchase.

Table 7 *continued.* PRESENT WORTH of an ESTATE, ANNUITY, or a LEASE, held on the *longest of Three Lives,* according to the *Northampton Table of Mortality.*

Note.—The Rate of Interest shown in this Table is that which a purchaser may make of his money, and get back the Principal, provided he can re-invest at the same rate.

Ages of the Lives.	Years Purchase at 3 p. cent.	4 p. cent.	5 p. cent.	6 p. cent.	Ages of the Lives.	Years Purchase at 3 p. cent.	4 p. cent.	5 p. cent.	6 p. cent.
30 35 55	21.1	18.2	15.9	14.1	40 45 75	18.2	16.	14.2	12.8
30 35 65	20.9	18.	15.7	14.	**40 50 50**	**19.**	**16.7**	**14.9**	**13.3**
30 35 75	20.7	17.9	15.6	13.8	40 50 60	18.3	16.2	14.4	12.9
30 40 40	**21.8**	**18.6**	**16.3**	**14.3**	40 50 70	17.8	15.7	14.	12.6
30 40 50	21.	18.2	15.9	14.1	**40 55 55**	**18.3**	**16.2**	**14.2**	**12.8**
30 40 60	20.6	17.8	15.6	13.9	40 55 65	17.5	15.5	13.8	12.6
30 40 70	20.2	17.5	15.4	13.6	40 55 75	17.3	15.3	13.7	12.4
30 45 45	**21.1**	**18.2**	**16.**	**14.2**	**40 60 60**	**17.6**	**15.6**	**13.7**	**12.4**
30 45 55	20.2	17.6	15.5	13.7	40 60 70	16.9	15.0	13.5	12.2
30 45 65	19.9	17.3	15.2	13.5	**40 65 65**	**16.6**	**14.7**	**13.2**	**12.4**
30 45 75	19.6	17.	14.9	13.3	40 65 75	16.2	14.4	12.9	11.8
30 50 50	**20.2**	**17.6**	**15.5**	**13.8**	40 70 70	16.2	14.5	13.	11.8
30 50 60	19.6	17.1	15.1	13.4	**50 50 50**	**17.9**	**15.9**	**14.2**	**12.8**
30 50 70	19.3	16.8	14.8	13.2	50 50 60	17.	15.2	13.6	12.3
30 55 55	**19.7**	**17.2**	**14.9**	**13.4**	50 50 70	16.4	14.6	13.2	12.
30 55 65	18.8	16.4	14.5	13.2	**50 55 55**	**17.**	**15.2**	**13.6**	**12.3**
30 55 75	18.7	16.3	14.3	13.	50 55 65	15.9	14.3	12.9	11.9
30 60 60	**19.1**	**16.7**	**14.6**	**13.**	50 55 75	15.6	14.	12.7	11.6
30 60 70	18.6	16.3	14.4	12.9	**50 60 60**	**16.**	**14.4**	**12.8**	**11.7**
30 65 65	**18.3**	**16.**	**14.1**	**13.**	50 60 70	15.2	13.7	12.4	11.4
30 65 75	17.9	15.7	13.9	12.5	**50 65 65**	**14.8**	**13.4**	**12.2**	**11.5**
30 70 70	18.	15.8	14.	12.5	50 65 75	14.3	12.9	11.8	10.9
40 40 40	**20.9**	**18.**	**15.8**	**14.**	**50 70 70**	**14.3**	**12.9**	**11.8**	**10.8**
40 40 50	20.	17.4	15.4	13.7	60 60 60	14.6	13.2	12.0	11.0
40 40 60	19.4	17.	15.	13.4	60 60 70	13.5	12.4	11.4	10.5
40 40 70	19.	16.6	14.7	13.1	**60 65 65**	**13.2**	**12.1**	**11.1**	**10.7**
40 45 45	**20.**	**17.5**	**15.5**	**13.8**	60 65 75	12.4	11.4	10.5	9.8
40 45 55	19.1	16.7	14.9	13.3	**60 70 70**	**12.3**	**11.3**	**10.5**	**9.7**
40 45 65	18.6	16.4	14.5	13.	70 70 70	10.5	9.8	9.2	8.6

EXAMPLE. An Estate, Annuity, or a Lease, to determine on the death of the longest of Three Lives, aged 30, 45, and 65 years, to pay 3 per cent. and get back the Principal, is worth 19.9 years' purchase. To make 4 per cent. it is worth 17.3 years' purchase.

Table 8. AMOUNT of FINE to be paid for RENEWING any number of years lapsed IN A LEASE originally granted for 10 years.

Note.—The rate of Interest shown in this Table is that which a Purchaser may make of his money, provided he can re-invest the surplus at the same rate, so as to replace the Fine at the end of his Lease.

Years Purchase at				Years.	Years Purchase at			
3 per cent.	4 per cent.	5 per cent.	6 per cent.		7 per cent.	8 per cent.	10 per cent.	17.950 per cent.
.7	.7	.6	.6	1	.5	.5	.4	.2
1.5	1.4	1.3	1.1	2	1.1	1.	.8	.4
2.3	2.1	1.9	1.8	3	1.6	1.5	1.3	.7
3.1	**2.9**	**2.6**	**2.4**	**4**	**2.3**	**2.1**	**1.8**	**1.**
3.9	3.7	3.4	3.1	5	2.9	2.7	2.4	1.4
4.8	4.5	4.2	3.9	6	3.6	3.4	3.	1.8
5.7	5.3	5.0	4.7	7	4.4	4.1	3.7	2.3
6.6	**6.2**	**5.9**	**5.5**	**8**	**5.2**	**4.9**	**4.4**	**2.9**
7.6	7.1	6.8	6.4	9	6.1	5.8	5.2	3.7
8.5	8.1	7.7	7.4	10	7.0	6.7	6.1	4.5

EXAMPLE.—The Fine which a Tenant should pay for the renewal of 5 years lapsed in his Lease of 10 years, in order that he may make 4 per cent. for the money he advances, is 3.7 years' purchase of the Net Annual Income.

Table 9. AMOUNT OF FINE to be paid for RENEWING any number of years lapsed in a LEASE originally granted for Twenty Years.

Note.—This Table shows the rate of Interest which a person may make of his money, provided he can re-invest the surplus at the same rate of Interest, so as to re-place the Fine at the end of the Lease.

Years Purchase at				Years.	Years Purchase at			
3 per cent.	4 per cent.	5 per cent.	6 per cent.		7 per cent.	8 per cent.	10 per cent.	£12 6 1 per cent.
.6	.5	.4	.3	1	.3	.2	.1	.1
1.1	.9	.8	.6	2	.5	.4	.3	.2
1.7	1.4	1.2	1.	3	.8	.7	.5	.3
2.3	**1.9**	**1.6**	**1.4**	**4**	**1.1**	**1.**	**.7**	**.5**
2.9	2.5	2.1	1.8	5	1.5	1.3	.9	.6
3.6	3.	2.6	2.2	6	1.8	1.6	1.1	.8
4.2	3.6	3.1	2.6	7	2.2	1.9	1.4	1.
4.9	**4.2**	**3.6**	**3.1**	**8**	**2.7**	**2.3**	**1.7**	**1.2**
5.6	4.8	4.2	3.6	9	3.1	2.7	2.	1.5
6.3	5.5	4.7	4.1	10	3.6	3.1	2.4	1.7
7.1	6.2	5.4	4.7	11	4.1	3.6	2.8	2.1
7.9	**6.9**	**6.**	**5.3**	**12**	**4.6**	**4.**	**3.2**	**2.4**
8.6	7.6	6.7	5.9	13	5.2	4.6	3.6	2.8
9.5	8.3	7.4	6.6	14	5.8	5.2	4.2	3.3
10.3	9.1	8.1	7.3	15	6.5	5.8	4.7	3.8
11.2	**10.**	**8.9**	**8.**	**16**	**7.2**	**6.5**	**5.3**	**4.3**
12.	10.8	9.7	8.8	17	8.	7.2	6.	4.9
13.	11.7	10.6	9.7	18	8.8	8.	6.8	5.6
13.9	12.6	11.5	10.5	19	9.7	8.9	7.6	6.4
14.9	**13.6**	**12.5**	**11.5**	**20**	**10.6**	**9.8**	**8.5**	**7.3**

EXAMPLE. The Fine a Tenant should pay for the Renewal of 12 years lapsed in a Lease originally granted for 20 years, to make 4 per cent. of the money he advances, is 6.9 years' purchase of the *net Income*.

Table 10. AMOUNT OF FINE to be paid for RENEWING any number of years lapsed in a LEASE originally granted for Twenty-one Years.

Note.—This Table shows the rate of Interest which a person may make of his money, provided he can re-invest the surplus at the same rate of Interest, so as to replace the Fine at the end of the Lease.

Years Purchase at				Years.	Years Purchase at			
3 per cent.	4 per cent.	5 per cent.	6 per cent.		7 per cent.	8 per cent.	10 per cent.	11.564 OR £11 11 3 per cent.
.5	.4	.4	.3	1	.2	.2	.1	.1
1.1	.9	.7	.6	2	.5	.4	.3	.2
1.7	1.4	1.1	.9	3	.8	.6	.4	.3
2.2	**1.9**	**1.5**	**1.3**	**4**	**1.1**	**.9**	**.6**	**.5**
2.9	2.4	2.	1.7	5	1.4	1.2	.8	.6
3.5	2.9	2.4	2.1	6	1.7	1.5	1.	.8
4.1	3.5	2.9	2.5	7	2.1	1.8	1.3	1.0
4.8	**4.**	**3.4**	**2.9**	**8**	**2.5**	**2.1**	**1.5**	**1.2**
5.5	4.6	4.	3.4	9	2.9	2.5	1.8	1.5
6.2	5.3	4.5	3.9	10	3.3	2.9	2.2	1.7
6.9	5.9	5.1	4.4	11	3.8	3.3	2.5	2.
7.6	**6.6**	**5.7**	**5.**	**12**	**4.3**	**3.8**	**2.9**	**2.4**
8.4	7.3	6.4	5.6	13	4.9	4.3	3.3	2.7
9.2	8.	7.	6.2	14	5.4	4.8	3.8	3.2
10.	8.8	7.7	6.8	15	6.1	5.3	4.3	3.6
10.8	**9.6**	**8.5**	**7.6**	**16**	**6.7**	**6.0**	**4.9**	**4.1**
11.7	10.4	9.3	8.3	17	7.4	6.7	5.5	4.7
12.6	11.3	10.1	9.1	18	8.2	7.4	6.2	5.4
13.5	12.1	11.	9.9	19	9.	8.2	6.9	6.1
14.4	**13.1**	**11.9**	**10.8**	**20**	**9.9**	**9.1**	**7.7**	**6.9**
15.4	14.	12.8	11.8	21	10.8	10.	8.6	7.8

EXAMPLE. The amount of Fine which a Tenant should pay for the Renewal of 12 years lapsed in a Lease originally granted for 21 years, to make 4 per cent. of the money he advances, is 6.6 years purchase of the Net Annual Income.

Table 11. AMOUNT OF FINE to be paid for RENEWING any number of years lapsed in a LEASE originally granted for 40 years.

Note.—This Table shows the rate of Interest which a person may make of his money provided he can re-invest the surplus, beyond the available interest, at the same rate, so as to replace the Fine at the end of the Lease.

Years Purchase at				Years.	Years Purchase at			
3 per cent.	4 per cent.	5 per cent.	6 per cent.		7 per cent.	8 per cent.	9 per cent.	10 per cent.
.3	.2	.1	.1	1	.1	.0	.0	.0
.6	.4	.3	.2	2	.1	.1	.1	.0
.9	.6	.4	.3	3	.2	.1	.1	.1
1.3	**.9**	**.6**	**.4**	**4**	**.3**	**.2**	**.1**	**.1**
1.6	1.1	.8	.5	5	.4	.3	.2	.1
2.	1.4	1.	.7	6	.5	.3	.2	.2
2.3	1.6	1.2	.8	7	.6	.4	.3	.2
2.7	**1.9**	**1.4**	**1.**	**8**	**.7**	**.5**	**.4**	**.3**
3.1	2.2	1.6	1.1	9	.8	.6	.4	.3
3.5	2.5	1.8	1.3	10	.9	.7	.5	.4
3.9	2.8	2.	1.5	11	1.1	.8	.6	.4
4.4	**3.1**	**2.3**	**1.6**	**12**	**1.2**	**.9**	**.6**	**.5**
4.8	3.5	2.5	1.8	13	1.3	1.	.7	.5
5.2	3.8	2.8	2.	14	1.5	1.1	.8	.6
5.7	4.2	3.1	2.3	15	1.7	1.2	.9	.7
6.2	**4.5**	**3.4**	**2.5**	**16**	**1.9**	**1.4**	**1.1**	.8
6.7	4.9	3.7	2.7	17	2.1	1.6	1.2	.9
7.2	5.3	4.	3.	18	2.3	1.7	1.3	1.
7.7	5.8	4.3	3.3	19	2.5	1.9	1.5	1.1
8.2	**6.2**	**4.7**	**3.6**	**20**	**2.7**	**2.1**	**1.6**	**1.3**
8.8	6.7	5.1	3.9	21	3.	2.3	1.8	1.4
9.4	7.1	5.5	4.2	22	3.3	2.6	2.	1.6
9.9	7.6	5.9	4.6	23	3.6	2.8	2.2	1.8
10.6	**8.1**	**6.3**	**4.9**	**24**	**3.9**	**3.1**	**2.4**	**2.**
11.2	8.7	6.8	5.3	25	4.2	3.4	2.7	2.2
11.8	9.2	7.3	5.8	26	4.6	3.7	3.	2.4
12.5	9.8	7.8	6.2	27	5.	4.	3.3	2.7
13.2	**10.4**	**8.3**	**6.7**	**28**	**5.4**	**4.4**	**3.6**	**3.**
13.9	11.	8.9	7.2	29	5.8	4.8	4.	3.3
14.6	11.7	9.4	7.7	30	6.3	5.2	4.3	3.6
15.3	12.4	10.1	8.2	31	6.8	5.7	4.8	4.
16.1	**13.1**	**10.7**	**8.8**	**32**	**7.4**	**6.2**	**5.2**	**4.4**
16.9	13.8	11.4	9.5	33	7.9	.6.7	5.7	4.9
17.7	14.6	12.1	10.1	34	8.6	7.3	6.3	5.4
18.5	15.3	12.8	10.8	35	9.2	7.9	6.9	6.
19.4	**16.2**	**13.6**	**11.6**	**36**	**9.9**	**8.6**	**7.5**	**6.6**
20.3	17.	14.4	12.4	37	10.7	9.3	8.2	7.3
21.2	17.9	15.3	13.2	38	11.5	10.1	9.	8.
22.1	18.8	16.2	14.1	39	12.4	11.	9.8	8.9
23.1	**19.8**	**17.2**	**15.**	**40**	**13.3**	**11.9**	**10.8**	**9.8**

EXAMPLE. The amount of Fine which a Tenant should pay for the renewal of 20 years lapsed in a Lease originally granted for 40 years, to make 4 per cent. of the money he advances is 6.2 years' purchase of the net annual Income.

Table 12. AMOUNT of FINE to be paid for RENEWING with ONE LIFE the LEASE of an ESTATE originally granted on THREE LIVES.

Note.—This Table shows the rate of Interest which a Purchaser may make of his money, provided he can re-invest the Surplus Income, beyond the Interest on the Purchase Money outstanding, at the same rate of Interest.

Years Purchase.		Life put in.	Ages of Lives in possession.	Years Purchase.		Years Purchase.		Life put in.	Ages of Lives in possession.	Years Purchase.		Years Purchase.		Life put in.	Ages of Lives in possession.	Years Purchase.	
3 per cent.	4 per cent.			5 per cent.	6 per cent.	3 per cent.	4 per cent.			5 per cent.	6 per cent.	3 per cent.	4 per cent.			5 per cent.	6 per cent.
2.8	2.		25—25	1.5	1.1	2.5	1.8		25—25	1.4	1.	2.2	1.6		25—25	1.2	.9
3.3	2.3		25—35	1.7	1.2	2.9	2.1		25—35	1.5	1.2	2.5	1.8		25—35	1.4	1.1
4.1	2.9		25—45	2.	1.5	3.6	2.6		25—45	1.8	1.4	3.1	2.3		25—45	1.6	1.3
4.6	**3.4**		**25—55**	**2.4**	**1.8**	**4.1**	**3.**		**25—55**	**2.3**	**1.7**	**3.6**	**2.7**		**25—55**	**2.1**	**1.5**
5.2	3.8		25—65	2.8	2.2	4.6	3.4		25—65	2.6	2.1	4.1	3.1		25—65	2.4	1.9
5.5	4.1		25—75	3.1	2.4	4.9	3.7		25—75	2.8	2.2	4.4	3.3		25—75	2.6	2.
4.1	2.9		35—35	2.1	1.5	3.6	2.6		35—35	1.8	1.4	3.1	2.3		35—35	1.6	1.3
4.8	**3.3**		**35—45**	**2.4**	**1.9**	**4.3**	**3.1**		**35—45**	**2.2**	**1.8**	**3.7**	**2.8**		**35—45**	**2.1**	**1.6**
5.3	3.8		35—55	2.8	2.2	4.7	3.5		35—55	2.6	2.	4.2	3.1		35—55	2.4	1.9
6.	4.4		35—65	3.3	2.6	5.4	4.		35—65	3.1	2.5	4.9	3.7		35—65	2.8	2.3
6.6	4.9	10	35—75	3.8	3.	6.	4.5	15	35—75	3.5	2.8	5.4	4.1	20	35—75	3.2	2.6
5.7	**3.9**		**45—45**	**2.9**	**2.3**	**5.1**	**3.5**		**45—45**	**2.6**	**2.2**	**4.4**	**3.2**		**45—45**	**2.4**	**2.**
6.4	4.7		45—55	3.5	2.7	5.7	4.2		45—55	3.2	2.5	5.1	3.8		45—55	2.9	2.3
7.3	5.4		45—65	4.1	3.2	6.6	5.		45—65	3.8	3.1	6.	4.5		45—65	3.5	2.9
7.9	5.9		45—75	4.6	3.6	7.2	5.5		45—75	4.2	3.4	6.5	5.		45—75	3.9	3.2
7.7	**5.8**		**55—55**	**4.4**	**3.3**	**7.0**	**5.3**		**55—55**	**4.1**	**3.1**	**6.3**	**4.8**		**55—55**	**3.5**	**2.8**
8.7	6.5		55—65	5.	4.	7.9	6.		55—65	4.7	3.8	7.2	5.5		55—65	4.2	3.5
9.8	7.5		55—75	5.9	4.7	9.	7.		55—75	5.5	4.5	8.3	6.5		55—75	5.1	4.2
10.3	7.9		65—65	6.2	5.	9.6	7.5		65—65	5.9	4.7	8.8	6.9		65—65	5.5	4.4
11.6	**9.1**		**65—75**	**7.2**	**5.9**	**10.8**	**8.5**		**65—75**	**6.8**	**5.6**	**9.9**	**7.9**		**65—75**	**6.3**	**5.2**

EXAMPLE.—The amount of Fine which a Tenant should pay for putting in a new life, aged 15, in a Lease originally granted on three lives, one of which has dropped, the ages of the lives in possession being 45 and 75, to make 4 per cent. of his money, is 5.5 years' purchase of the Net Annual Income

Table 13. PRESENT VALUE of the PERPETUITY of one year's Rent or Fine, payable at every interval of years stated below.

Years Purchase at			Interval of Years.	Years Purchase at		
3 per cent.	**4** per cent.	**5** per cent.		**6** per cent.	**8** per cent.	**10** per cent.
16.4	12.3	9.8	2	8.1	6.	4.8
10.8	8.	6.3	3	5.2	3.9	3.
8.	5.9	4.6	4	3.8	2.8	2.2
6.3	**4.6**	**3.6**	**5**	**3.**	**2.1**	**1.6**
5.2	3.8	2.9	6	2.4	1.7	1.3
4.3	3.2	2.5	7	2.	1.4	1.1
2.9	2.1	1.6	10	1.3	.9	.6
2.	**1.4**	**1.**	**14**	**.8**	**.5**	**.4**
1.2	.8	.6	20	.5	.3	.2
1.2	.8	.6	21	.4	.2	.2
.4	.3	.2	40	.1	.0	.0

EXAMPLE.—The present* worth of the perpetuity of one year's Rent or Fine, payable every 10 years, is at 4 per cent. 2.1 years' purchase.

* That is to say, immediately after a Fine has been paid for renewal.

Table 14. PRESENT VALUE of the REVERSION to a FREEHOLD ESTATE, or a PERPETUITY, after any given number of years not exceeding sixty.

Years Purchase at				After these Years.	Years Purchase at			
3 per cent.	**4** per cent.	**5** per cent.	**6** per cent.		**7** per cent.	**8** per cent.	**9** per cent.	**10** per cent.
32.4	24.	19.	15.7	1	13.4	11.6	10.2	9.1
31.4	23.1	18.1	14.8	2	12.5	10.7	9.4	8.3
30.5	22.2	17.3	14.	3	11.7	9.9	8.6	7.5
29.6	21.4	16.5	13.2	4	10.9	9.2	7.9	6.8
28.8	**20.5**	**15.7**	**12.5**	**5**	**10.2**	**8.5**	**7.2**	**6.2**
27.9	19.8	14.9	11.7	6	9.5	7.9	6.6	5.6
27.1	19.	14.2	11.1	7	8.9	7.3	6.1	5.1
26.3	18.3	13.5	10.5	8	8.3	6.8	5.6	4.7
25.5	17.6	12.9	9.9	9	7.8	6.3	5.1	4.2
24.8	**16.9**	**12.3**	**9.3**	**10**	**7.3**	**5.8**	**4.7**	**3.9**
24.1	16.2	11.7	8.8	11	6.8	5.4	4.3	3.5
23.4	15.6	11.1	8.3	12	6.3	5.	4.	3.2
22.7	15.	10.6	7.8	13	5.9	4.6	3.6	2.9
22.	14.4	10.1	7.4	14	5.5	4.3	3.3	2.6
21.4	**13.9**	**9.6**	**7.**	**15**	**5.2**	**3.9**	**3.1**	**2.4**
20.8	13.3	9.2	6.6	16	4.8	3.6	2.8	2.2
20.2	12.8	8.7	6.2	17	4.5	3.4	2.6	2.
19.6	12.3	8.3	5.8	18	4.2	3.1	2.4	1.8
19.	11.9	7.9	5.5	19	3.9	2.9	2.2	1.6
18.5	**11.4**	**7.5**	**5.2**	**20**	**3.7**	**2.7**	**2.**	**1.5**
17.9	11.	7.2	4.9	21	3.4	2.5	1.8	1.4
17.4	10.5	6.8	4.6	22	3.2	2.3	1.7	1.2
16.9	10.1	6.5	4.4	23	3.0	2.1	1.5	1.1
16.4	9.8	6.2	4.1	24	2.8	2.	1.4	1.
15.9	**9.4**	**5.9**	**3.9**	**25**	**2.6**	**1.8**	**1.3**	**.9**
15.5	9.	5.6	3.7	26	2.5	1.7	1.2	.8
15.	8.7	5.4	3.5	27	2.3	1.6	1.1	.8
14.6	8.3	5.1	3.3	28	2.1	1.4	1.	.7
14.1	8.	4.9	3.1	29	2.	1.3	.9	.6
13.7	**7.7**	**4.6**	**2.9**	**30**	**1.9**	**1.2**	**.8**	**.6**

EXAMPLE. The present worth of the Reversion to a Freehold Estate after 25 years, to make 4 per cent. interest is 9.4 years' purchase of the net annual rent.

Table 14 *continued.* PRESENT VALUE of the REVERSION to a FREEHOLD ESTATE, or a PERPETUITY, after any given number of years not exceeding sixty.

Years Purchase at				After these Years.	Years Purchase at			
3 per cent.	4 per cent.	5 per cent.	6 per cent.		7 per cent.	8 per cent.	9 per cent.	10 per cent.
13.3	7.4	4.4	2.7	31	1.8	1.1	.8	.5
12.9	7.1	4.2	2.6	32	1.6	1.1	.7	.5
12.6	6.8	4.	2.4	33	1.5	1.	.6	.4
12.2	6.6	3.8	2.3	34	1.4	.9	.6	.4
11.8	**6.3**	**3.6**	**2.2**	**35**	**1.3**	**.8**	**.5**	**.4**
11.5	6.1	3.5	2.	36	1.2	.8	.5	.3
11.2	5.9	3.3	1.9	37	1.2	.7	.5	.3
10.8	5.6	3.1	1.8	38	1.1	.7	.4	.3
10.5	5.4	3.	1.7	39	1.	.6	.4	.3
10.2	**5.2**	**2.8**	**1.6**	**40**	**1.**	**.6**	**.4**	**.2**
9.9	5.	2.7	1.5	41	.9	.5	.3	.2
9.6	4.8	2.6	1.4	42	.8	.5	.3	.2
9.4	4.6	2.5	1.4	43	.8	.5	.3	.2
9.1	4.5	2.3	1.3	44	.7	.4	.3	.2
8.8	**4.3**	**2.2**	**1.2**	**45**	**.7**	**.4**	**.2**	**.1**
8.6	4.1	2.1	1.1	46	.6	.4	.2	.1
8.3	4.	2.	1.1	47	.6	.3	.2	.1
8.1	3.8	1.9	1.	48	.6	.3	.2	.1
7.8	3.7	1.8	1.	49	.5	.3	.2	.1
7.6	**3.5**	**1.7**	**.9**	**50**	**.5**	**.3**	**.1**	**.1**
7.4	3.4	1.7	.9	51	.5	.2	.1	.1
7.2	3.3	16	.8	52	.4	.2	.1	.1
7.	3.1	1.5	.8	53	.4	.2	.1	.1
6.8	3.	1.4	.7	54	.4	.2	.1	.1
6.6	2.9	**1.4**	**.7**	**55**	**.3**	**.2**	**.1**	**.1**
6.4	2.8	1.3	.6	56	.3	.2	.1	.0
6.2	2.7	1.2	.6	57	.3	.2	.1	.0
6.	2.6	1.2	.6	58	.3	.1	.1	.0
5.8	2.5	1.1	.5	59	.3	.1	.1	.0
5.7	**2.4**	**1.1**	**.5**	**60**	**.2**	**.1**	**.1**	**.0**

EXAMPLE. The present worth of the Reversion to a Freehold Estate after 60 years, to make 4 per cent. interest, is 2.4 years' purchase of the net annual rent.

Table 15. PRESENT VALUE of a REVERSIONARY ESTATE in FEE after the Life of a person of a given age, at the several rates of 3, 4, 5, 6, 7, and 8 per cent. Interest.

Years Purchase at			Age in Possession.	Years Purchase at		
3 per cent.	**4** per cent.	**5** per cent.		**6** per cent.	**7** per cent.	**8** per cent.
12.9	7.8	5.2	5	3.7	2.8	2.2
12.7	7.5	4.9	10	3.4	2.5	1.9
13.7	8.2	5.4	15	3.8	2.8	2.2
14.7	**9.**	**6.**	**20**	**4.3**	**3.2**	**2.5**
15.5	9.6	6.4	25	4.6	3.4	2.7
16.4	10.2	6.9	30	5.	3.7	2.9
17.4	11.	7.5	35	5.4	4.1	3.2
18.5	**11.8**	**8.2**	**40**	**6.**	**4.5**	**3.6**
19.6	12.7	8.9	45	6.6	5.	4.
20.9	13.7	9.7	50	7.2	5.6	4.5
22.2	14.8	10.6	55	8.	6.2	5.
23.6	**16.**	**11.6**	**60**	**8.8**	**7.**	**5.6**
25.	17.2	12.7	65	9.8	7.8	6.4
26.6	18.6	14.	70	11.	8.9	7.3
28.1	20.	15.3	75	12.1	9.9	8.3
29.6	**21.4**	**16.5**	**80**	**13.3**	**11.**	**9.3**
30.7	22.5	17.5	85	14.3	11.9	10.2
31.5	23.2	18.3	90	15.	12.6	10.9
33.1	24.8	19.8	95	16.4	14.	12.3

EXAMPLE. The present value of a Freehold Reversionary Estate or of an *Advowson* subject to the life of a person aged 60, at 4 per cent., is 16 years' purchase. At 5 per cent., it is worth 11.6 years' purchase.

Table 16. Showing the PRESENT VALUE of a REVERSIONARY ESTATE in FEE after the longest of Two Lives of given ages at the several rates of 3, 4, 5, and 6 per cent. Interest.

Years Purchase at 3 per cent.	Years Purchase at 4 per cent.	Ages.	Years Purchase at 5 per cent.	Years Purchase at 6 per cent.
8.3	**4.2**	**10 — 10**	**2.4**	**1.4**
9.2	4.8	10 — 20	2.8	1.7
9.9	5.3	10 — 30	3.1	1.9
10.6	5.8	10 — 40	3.5	2.2
11.3	6.3	10 — 50	3.9	2.5
11.8	6.8	10 — 60	4.2	2.8
12.3	7.1	10 — 70	4.5	3.1
12.5	7.4	10 — 80	4.7	3.3
10.2	**5.5**	**20 — 20**	**3.2**	**2.**
11.	6.1	20 — 30	3.6	2.3
11.9	6.7	20 — 40	4.1	2.7
12.8	7.3	20 — 50	4.6	3.
13.5	7.9	20 — 60	5.1	3.4
14.1	8.4	20 — 70	5.5	3.8
14.5	8.8	20 — 80	5.8	4.1
12.1	**6.8**	**30 — 30**	**4.1**	**2.7**
13.1	7.5	30 — 40	4.7	3.1
14.1	8.3	30 — 50	5.3	3.5
15.	9.	30 — 60	5.9	4.
15.7	9.6	30 — 70	6.3	4.4
16.2	10.	30 — 80	6.7	4.8
14.4	**8.4**	**40 — 40**	**5.3**	**3.6**
15.6	9.4	40 — 50	6.1	4.1
16.7	10.3	40 — 60	6.8	4.7
17.6	11.	40 — 70	7.4	5.3
18.2	11.5	40 — 80	7.9	5.7
17.2	10.6	50 — 50	7.	4.9
18.6	**11.7**	**50 — 60**	**7.9**	**5.6**
19.7	12.7	50 — 70	8.8	6.4
20.5	13.3	50 — 80	9.4	6.9
20.4	**13.1**	**60 — 60**	**9.1**	**6.6**
22.	14.5	60 — 70	10.3	7.6
23.	15.4	60 — 80	11.1	8.4
24.1	**16.4**	**70 — 70**	**11.9**	**9.**

EXAMPLE. A Reversionary Freehold Estate, after the longest of two lives aged 30 and 50, at 3 per cent., is worth 14.1 years' purchase.
At 4 per cent., it is worth 8.3 years' purchase.

Table 17. PRESENT VALUE of a REVERSIONARY ESTATE or ANNUITY on a single Life, after any other single Life now in Possession, at the several rates of 3, 4, 5, and 6 per cent. Interest.

Years Purchase at 3 per cent.	Years Purchase at 4 per cent.	Age of Life in Reversion.	Age of Life in Possession.	Years Purchase at 5 per cent.	Years Purchase at 6 per cent.
6.5	**4.9**	10	**30**	**3.8**	**3.0**
7.9	6.		40	4.7	3.7
9.6	7.4		50	5.9	4.7
11.7	9.2		60	7.4	6.
14.3	11.5		70	9.4	7.9
17.	14.		80	11.7	10.
5.4	**4.2**	20	**30**	**3.3**	**2.7**
6.5	5.1		40	4.1	3.3
8.1	6.4		50	5.1	4.2
10.	8.		60	6.5	5.4
12.5	10.2		70	8.5	7.1
15.1	12.6		80	10.7	9.2
4.3	**3.5**	30	**30**	**2.8**	**2.3**
5.4	4.3		40	3.5	2.9
6.8	5.5		50	4.5	3.7
8.5	7.		60	5.8	4.8
10.9	9.1		70	7.6	6.5
13.4	11.4		80	9.8	8.5
3.3	**2.7**	40	**30**	**2.3**	**1.9**
4.1	3.4		40	2.8	2.4
5.3	4.4		50	3.7	3.1
6.8	5.7		60	4.8	4.1
9.0	7.6		70	6.5	5.7
11.4	9.9		80	8.6	7.6
2.3	**1.9**	50	**30**	**1.7**	**1.5**
2.8	2.4		40	2.1	1.8
3.7	3.2		50	2.7	2.4
5.	4.3		60	3.7	3.2
6.9	6.		70	5.2	4.6
9.1	8.		80	7.1	6.4
1.4	**1.2**	60	**30**	**1.1**	**1.0**
1.8	1.5		40	1.4	1.2
2.3	2.0		50	1.8	1.6
3.2	2.8		60	2.5	2.2
4.6	4.1		70	3·7	3.3
6.6	**5.9**		80	5.4	4.9

EXAMPLE. A Reversionary Estate on a single life aged 30, after a single life in possession aged 60, at 3 per cent., is worth in present money, 8.5 years' purchase of the net Annual Income.

Table 18. PRESENT VALUE of a REVERSIONARY ANNUITY on a Single Life, to be nominated at the death of a person now in Possession, at the several rates of 3, 4, 5, and 6 per cent. Interest.

Years Purchase at		Ages of Life in Reversion.	Ages of Life in Possession.	Years Purchase at	
3 per cent.	**4** per cent.			**5** per cent.	**6** per cent.
8.8	**6.3**	25	**30**	**4.7**	**3.6**
9.9	7.3		40	5.5	4.3
11.2	8.5		50	6.6	5.3
12.6	9.9		60	7.9	6.4
14.2	11.5		70	9.5	7.9
15.8	13.2		80	11.2	9.6
8.3	**6.**	30	**30**	**4.5**	**3.5**
9.4	7.		40	5.3	4.2
10.6	8.1		50	6.4	5.1
12.	9.4		60	7.6	6.2
13.5	11.		70	9.1	7.7
15.	12.6		80	10.8	9.3
7.8	**5.7**	35	**30**	**4.3**	**3.4**
8.8	6.6		40	5.1	4.
10.	7.7		50	6.1	4.9
11.3	9.		60	7.3	6.
12.8	10.5		70	8.7	7.4
14.1	12.		80	10.3	8.9
7.3	**5.4**	40	**30**	**4.1**	**3.2**
8.2	6.2		40	4.8	3.8
9.3	7.3		50	5.8	4.7
10.5	8.4		60	6.9	5.7
11.8	9.8		70	8.3	7.
13.2	11.3		80	9.8	8.5
6.7	**5.**	45	**30**	**3.8**	**3.**
7.6	5.8		40	4.5	3.6
8.6	6.7		50	5.4	4.4
9.7	7.8		60	6.4	5.4
10.9	9.2		70	7.8	6.6
12.1	10.5		80	9.2	8.1
6.1	**4.6**	50	**30**	**3.6**	**2.8**
6.9	5.3		40	4.2	3.4
7.8	6.2		50	5.	4.1
8.8	7.2		60	6.	5.
9.9	8.4		70	7.2	6.2
11.	9.6		80	8.5	7.5

EXAMPLE. The present value of a Reversionary Annuity on a Single Life aged 30, to be nominated at the death of a person, now in possession aged 50, to pay 3 per cent., is worth in present money, 10.6 years' purchase of the net annual income. At 4 per cent. it would be 8.1 years' purchase.

Table 19. PRESENT VALUE of £1, payable at the death of a person of a given age.

3 PER CENT.			4 PER CENT.			5 PER CENT.		
Age.	By the Northampton Tables of Mortality.	By the Carlisle Tables of Mortality.	Age.	By the Northampton Tables of Mortality.	By the Carlisle Tables of Mortality.	Age.	By the Northampton Tables of Mortality.	By the Carlisle Tables of Mortality.
10	.369	.286	10	.287	.208	10	.232	.159
15	.398	.313	15	.315	.232	15	.258	.180
20	.428	.339	20	.345	.255	20	.285	.199
25	.452	.369	25	.368	.283	25	.306	.224
30	**.478**	**.401**	**30**	**.393**	**.313**	**30**	**.330**	**.251**
35	.507	.434	35	.422	.345	35	.357	.280
40	.538	.472	40	.454	.382	40	.389	.315
45	.572	.508	45	.489	.419	45	.424	.350
50	**.609**	**.554**	**50**	**.528**	**.466**	**50**	**.463**	**.409**
55	.646	.609	55	.569	.527	55	.506	.460
60	.686	.665	60	.614	.590	60	.553	.527
65	.729	.711	65	.663	.642	65	.606	.583
70	**.775**	**.763**	**70**	**.717**	**.703**	**70**	**.666**	**.651**
75	.819	.810	75	.771	.760	75	.726	.715
80	.861	.843	80	.821	.800	80	.785	.761
85	.895	.877	85	.864	.842	85	.835	.809
90	**.919**	**.898**	**90**	**.894**	**.869**	**90**	**.870**	**.841**

EXAMPLE. £1 payable at the death of a person aged 55 years is worth, in present money at 5 per cent., according to the Northampton Tables of Mortality .506, or by the Carlisle Tables .460.

E. G. £100 is worth £50.6 or £46.

£1000 is worth £506 or £460.

MEMORANDA

As Facts to assist the Memory in matters of Calculations and Valuations.*

In respect to the value of freehold land, it is generally considered 30 to 33 years' purchase	3 per cent.
Freehold ground-rent, 25 to 30 years' purchase .	4 per cent.
Freehold houses and buildings, 1st and 2nd class, 18 to 20 years' purchase . . .	5 per cent.
Ditto, 3rd and 4th ditto, 16 years' purchase .	6 per cent.
For leasehold property refer to the Table for the term of years unexpired for long terms, 1st and 2nd class houses and buildings, 15 to 16 years' purchase	6 per cent.
For do. 2nd and 3rd do. 14 to 15 years' purchase	7 per cent.
For do. 3rd and 4th do. 12 to 13 years' purchase	8 per cent.
For do. 4th and 5th do. 11 to 12 years' purchase	9 per cent.
For do. 5th and 6th do. 10 years' purchase .	10 per cent.

Renewing Leases held under Deans and Chapters.

The Dean and Chapter of Westminster renew their leases, originally granted for FORTY YEARS, under the 8 per cent. Tables; the renewing fine of one year's rent payable by the tenant every fourteen years;—except for very superior houses at the West-end of the town, which are renewed under the 7 per cent. Tables. The renewing fine of 1½ years being payable by the tenant every fourteen years.

The Bishop of Winchester's Estates.

1½ Years renewing fine for 14 years lapsed in a lease originally granted for 40 years, 7 per cent. Tables if next the river; or, 1¼ year's fine in land 8 per cent.

* Chiefly extracted from the 13th Edition of *Inwood's Tables*.

City of London Leases, Scale of Ground Rents.

		s.	d.		d.
1st Class situation.	Per foot frontage .	5	0	Per foot deep .	3
2nd do.	ditto . .	4	0	ditto . .	2
3rd do.	ditto . .	3	0	ditto . .	1½
4th do.	ditto . .	2	0	ditto . .	1
5th do.	ditto . .	1	0	ditto . .	0½

Renewing fine, 7 years' ground rent every 14 years, for a term of 41 or 61 years.

Lessee to insure, repair, &c.

Purchase of Good Will in Retail Trade, &c.

If retail trade is carried on, giving credit, say, 1 year's purchase.

Ditto, as a ready money concern, say, 1½ year's purchase.

Ditto, trade subject to be annihilated, as public houses, say 2 to 3 years' purchase.

Calculating rent for fixtures, say 12½ per cent., or ⅛, being 2*s.* 6*d.* in the pound.

Allowance to Tenants for Repairs.

8 per cent. allow for amount of repairs for 21 years.
7 do. 31 do.

Or, generally, say, allow—

12 per cent.	for 12 years.
10 do.	15 do.
9 do.	18 do.
8 do.	23 do.
7 do.	33 do.
6 do.	above do.

Purchase of Land Tax.

To be made under the Land Tax Act at the price of the 3 per cent. consols, and to which add one-tenth to the amount, the income tax being now taken off.

Memorandum relative to the Valuation of Land.

43.560 feet superficial, an acre, at—

d.	£	s.	d.	
¼ per foot . . .	45	7	6	per acre.
½ do.	90	15	0	do.
¾ do.	136	2	0	do.
1 do.	181	10	0	do.
1¼ do.	226	17	6	do.
1½ do.	272	5	0	do.

Crown Lands.

The mode adopted in respect to the valuation for renewal of the crown leases,—allowance for repairs as under—

Houses £25 per annum, and under, .	10 per cent.
£25 to £50	6 per cent.
£50 to £100 . . .	7 per cent.
£100 and upwards . .	5 per cent.

The rack rent not an overstrained rent on account of crown property, and to encourage improvements, viz., *Calculation.*

Rack rent				£63 per annum.	
Deductions	£	*s.*	*d.*		
Present repair, £200 .	14	0	0		
Ordinary repairs, .	3	3	0		
Land tax . . .	3	3	0		
Insurance, £700 .	1	4	0		
Outgoings . . .	4	8	0		
				25	18 0
				£37	2 0

Say, £40 per annum clear rent.

Or, in another case,

Rack rent				£150 per annum.	
Deductions	£	*s.*	*d.*		
Present repairs, £250	17	10	0		
Ordinary repairs .	7	10	0		
Land tax . . .	5	12	0		
Insurance, £1500 .	3	7	6		
Contingencies . .	7	10	0		
	41	9	6		
				42	
				£108	

Crown leases, their custom under act of parliament, is to renew leases when within 20 years of being expired, not earlier, a new rent is then assessed taking $\frac{1}{3}$ fine, and $\frac{2}{3}$ rent, in order to secure more effectually the rent so reserved.

Increase of Population.

First 10 years of the century—1800 to 1810 Increase in England and Wales . .	15½ per cent.
1810 to 1820	17½ per cent.
1820 to 1830	15½ per cent.

Increase in population in England and Wales,	1801	9 millions.
	1810	10 millions.
	1821	12 millions.
Population of London		1½ millions.
Ditto, including environs		1¾ millions.

Out of 1000 persons there die annually about 30; and that the number of inhabitants of every city and county is renewed every thirty years, or nearly so.

Calculations have been made tending to show that the proportion of mortality is diminishing; which fact is confirmed by the returns in several great cities, proving incontestably the material amelioration which has taken place in great cities.

Mortality.

100 years since,	1	died	in	30.
50 do.	„ 1	„	in	40.
30 do.	„ 1	„	in	48.
20 do.	„ 1	„	in	52.
Present time,	1	„	in	60.

For Surveys and Valuations

Made in respect to the extensive improvements which have taken place in London,—Regent-street,—Strand,—the Commissioners of Improvements of Westminster,—the City and New London Bridge,—St. Katharine's Docks, and other improvements —the charges have been at the rate of ½ per cent., and 3 guineas for each surveyor attending to give evidence before a judge and jury.—It is usual to charge 1 per cent. for the first thousand pounds, and the remainder ½ per cent.

Her Majesty's Commissioners for Building Churches, for travelling expenses, allow 1*s.* 6*d.* per mile out, and the same back, but no expenses; and four journeys, not more, allowed to each church.

Rule for determining the Value of a Beneficial Lease for Years, so that the Purchaser may be able to make a given Interest on the Price paid, and replace his Capital at the expiration of the Lease.

In every question of this kind, it is evident that two circumstances may vary considerably: first, the interest which a purchaser may be considered entitled to make of his money, which in some descriptions of leasehold property, would be as low as 5, and in others as high as 8 or 9 per cent.; and, secondly, the rate of compound interest at which he may reckon with certainty upon employing the money annually laid by to replace his capital at the expiration of his lease, and which may be considered to range at about 3 or 4 per cent. Any formula, therefore, to be useful, must require the following data:—

1. The amount of the clear improved rent.
2. The rate of interest required on the purchase-money.
3. The rate of compound interest at which the money annually laid by to replace capital may be expected to be employed.
4. The length of the lease.

N.B. The two last data being given, tables of compound interest will give the amount of £1 per annum at the given rate of compound interest for the given number of years.

Now let

a = amount of clear improved rent;

b = amount of £1 per annum at n per cent. compound interest for r years (n standing for the rate of interest at which money may be expected to be employed; r standing for the number of years in the lease);

c = rate of interest per cent. required on purchase-money;

(These three may, of course, be considered as *known* quantities.)

x = amount of purchase money;

y = sum to be annually laid by at n per cent. compound interest, to replace capital at expiration of lease.

(These two are the unknown quantities.)

Then, from this statement, we shall have—

$b\,y = x$ for the amount of £1 per annum for the number of years of the lease at the given rate of compound interest *multiplied* by the number of pounds annually laid by, must equal the purchase-money;

$$\frac{c\,x}{100} + y = a \begin{cases} \text{for } \frac{c\,x}{100} = \text{annual interest on purchase-money,} \\ \text{since the annual interest on any sum} = \text{that sum} \\ \text{multiplied by the rate of interest, and divided by} \\ 100; \text{ and the annual interest on the purchase-} \\ \text{money added to the sum annually laid by to replace} \\ \text{capital, must} = \text{clear improved rent.} \end{cases}$$

From the first of these equations, $y, = \frac{x}{b}$, which, substituted in the second, gives

$$\frac{c\,x}{100} + \frac{x}{b} = a$$

$$\therefore x = \frac{100\,a\,b}{100 + b\,c}$$

$$\text{and } y = \frac{x}{b} = \frac{100\,a}{100 + b\,c}$$

From the foregoing formula, it follows that the value of any beneficial lease = the product of 100 multiplied into the amount of clear improved rent, multiplied again into the amount of £1 per annum for whatever number of years the lease may be, at the given rate of compound interest; the product of this continued multiplication being divided by 100, *added* to the product of the rate per cent. of interest required on purchase-money, multiplied by the aforesaid amount of £1 per annum, &c., &c. Therefore, if

$a = £500$

$b = 28{\cdot}6765$ { supposing $n = 3$ per cent., rate of comp. interest; „ $r = 21$ years, length of lease;

$c = 7$, rate per cent. of interest required on purchase-money; we shall have

$$x = \frac{100 \times 500 \times 28{\cdot}6765}{100 + 7 \times 28{\cdot}6765} = £4769\ 15\ 9\tfrac{1}{4};$$

$$y = \frac{100 \times 500}{100 + 7 \times 28{\cdot}6765} = £166\ 6\ 7\tfrac{1}{4};$$

and £500—166 6 $7\frac{1}{4}$ = £333 13 $4\frac{3}{4}$, which is the yearly interest at 7 per cent. on £4769 15 $9\frac{1}{4}$, the amount of the purchase-money; and £166 6 $7\frac{1}{4}$ annually laid by for 21 years, at 3 per cent. compound interest, will amount to £4769 15 $9\frac{1}{4}$; thereby replacing the principal at the end of the lease.

Where the question is as to the proper sum to be given for *renewing* any number of years lapsed in a lease, it is clear that the party wishing to renew gives up whatever may be the number of years remaining in his old lease, together with a certain sum

of money in consideration of receiving a new lease for the time agreed upon; and the value of the remainder of the old lease must be therefore deducted from the value of the new lease; and the remainder will be the proper sum to be given for the renewal. Thus, supposing it is wished to renew 14 years lapsed in a 21 years' lease, here the value of the remaining part of the lease = value of a lease for 7 years, and supposing, as before, that

a = £500;

b = 7·6625 $\begin{cases} n \text{ being} = 3 \text{ per cent. of compound interest;} \\ r \quad ,, \quad = 7 \text{ years, length of lease;} \end{cases}$

$c = 7$

$x = \dfrac{100 \times 500 \times 7{\cdot}6625}{100 + 7 \times 7{\cdot}6625}$ = £2493 13 $10\frac{1}{2}$; which is the value of the remaining 7 years of the old lease.

Now, the value of a new lease of 21 years, we shall find thus:—

a = £500;

b = 28·6765 $\begin{cases} n \text{ being} = 3 \text{ per cent. compound interest;} \\ r \quad ,, \quad = 21 \text{ years.} \end{cases}$

$c = 7$

$x = \dfrac{100 \times 500 \times 28{\cdot}6765}{100 + 7 \times 28{\cdot}6765}$ = £4769 15 $9\frac{1}{4}$; from which, if

we deduct value of remaining 7 years of old lease . .	2493 13 $10\frac{1}{2}$,
we shall have	£2276 1 $10\frac{3}{4}$ as the proper sum

to be paid for the renewal of the 14 years lapsed.

What Amount of Increased Rent should be given instead of Premium for the Renewal of any Number of Years lapsed in a Beneficial lease for Years?

The same data will suffice for solving this question which were required for determining the amount of premium to be paid for a renewal. In the first place, the value of the tenant's remaining interest in the old lease must be calculated by the first formula; and this value must be considered as the premium he pays for renewal; and the increased rent to be paid by him must therefore be such a sum as, if deducted from the amount of the clear annual improved rent, will leave a sufficient remainder to afford the tenant the given rate of interest upon the value of his remainder of lease, considered as capital, and also enable him to lay by a certain sum annually, which, at the given rate of compound interest, will replace this capital at the expiration of the new lease.

Supposing ∴

a = clear improved rent;

b = amount of £1 per annum for r years at n rate of compound interest, where r = number of years of new lease, n = rate of compound interest at which money can be safely employed; } Known quantities.

c = rate per cent. required on capital;

d = value of present interest in old lease;

x = increased annual rent to be paid instead of premium;

y = sum to be annually laid by to replace capital, (*i.e.* value of the remainder of old lease) at the expiration of new lease; } Unknown quantities.

then will

$b\,y = d$

$x = a - \frac{c\,d}{100} - y$ $\left\{\begin{array}{l}\frac{c\,d}{100} \text{ being the interest at the given rate upon} \\ \text{the capital sum.}\end{array}\right.$

$$\therefore y = \frac{d}{b}$$

$$x = a - \frac{c\,d}{100} - \frac{d}{b}.$$

From this formula it follows, that the proper increase of rent to be paid instead of a premium, for the renewal of any number of years lapsed in a beneficial lease = the amount of the clear improved rent, after deducting the quotient of the value of remainder of old lease, multiplied by the rate per cent. required on capital, and divided by 100; further deducting, also, the quotient of the value of remainder of old lease, divided by the amount of £1 per annum for the number of years in the new lease, at the given rate of compound interest; if ∴

a = £500 amount of clear improved rent;

$b = 28{\cdot}6765$ { n being = 3 per cent., rate of comp. interest; r „ = 21 years — length of new lease

$c = 7$ — rate per cent. required on capital;

d = £2493 13 $10\frac{1}{2}$ { This is on the supposition that 7 years remain unexpired of the old lease; the value being found by the first formula.

$$x = £500 - \frac{7 \times 2493\ 13\ 10\frac{1}{2}}{100} - \frac{2493\ 13\ 10\frac{1}{2}}{28{\cdot}6765}$$

x = £500 − 174 11 $1\frac{3}{4}$ − 86 19 8 = £500 − 261 10 $9\frac{3}{4}$;

∴ x = 238 9 $2\frac{1}{4}$; which is the proper amount of increased rent to be paid instead of premium, for the renewal of 14 years lapsed in a lease of which 7 years remain unexpired, of a property, the clear improved rent of which is £500 a-year.

There is only one more way in which renewals may be purchased, and that is, by paying for them partly by premium, and partly by increased rent; and the foregoing formula will solve any question of this kind. The amount, however, of one of these two quantities (*i.e.* the amount of the premium, or of the increased rent expected,) must of course be given, as they evidently vary inversely to each other. If the amount of premium expected be given, that amount must be added to the value of remaining part of old lease; and the last formula will find the additional rent to be paid.

Ex. gr., if, in the last case, a premium of £500 had been demanded, then—

a = £500 clear annual rent;

b = 28·6765, amount of £1, &c.;

c = 7, rate per cent. required on capital;

d = £2493 13 $10\frac{1}{2}$ + £500 (amount of prem.) = 2993 13 $10\frac{1}{2}$;

$$x = £500 - \frac{7 \times 2993\ 13\ 10\frac{1}{2}}{100} - \frac{2993\ 13\ 10\frac{1}{2}}{28{\cdot}6765};$$

x = £500 − 209 + 11 $1\frac{1}{4}$ − 104 7 $10\frac{3}{4}$ = £500 − 313 19 0 = £186 1 0.

∴ if £500 premium is demanded for a renewal of 14 years in a lease, of which 7 years remain unexpired, of a property, the clear annual rent of which is £500, the amount of increased rent to be paid for such renewal (in addition to such premium of £500,) is £186 1 0 annually.

If the amount of increased rent expected is given, such amount must, of course, be deducted from the amount of the clear improved rent, and the premium to be paid for the renewal may be calculated by the formula before given for that purpose; the clear improved rent being stated at its reduced amount.

CHAPTER XVIII.

VALUATIONS OF TILLAGES AND TENANT RIGHT.

THIS branch of practice attains its greatest importance in Surrey and parts of the adjacent counties, by reason of the number of items which the "custom of the country" (as it is technically termed,) in that neighbourhood, renders subject to the dealings of the valuator at a change of occupancy.

The following is a list of the various customs prevailing in the several counties of England, so far as I am acquainted with them, or they have in any way come under my observation.

Bedfordshire.—In this county an outgoing tenant generally has the option of sowing the wheat crop, if it be a Michaelmas holding, or of allowing the incoming tenant to enter upon the land sufficiently early to do it himself. And the same with respect to the spring corn, if the entry be at Lady-day. But in either case, the corn must be sown by Michaelmas or Lady-day, as may be. The valuation then takes place upon the labour, seed, and sowing. If the outgoing tenant exercises this option of sowing the corn against the wishes of an incoming tenant, the latter may exercise an option as to taking the crop.

The dung upon the premises at the expiration of the tenancy has to be left for the use of the incoming tenant without forming any item in the valuation.

Seed, sowing, and labour upon the grass seeds are valued, and labour upon the fallows, as well as the labour upon the lands prepared for spring corn not sown by an outgoing tenant at a Lady-day entry.

Berkshire.—The incoming tenant generally enters upon the land at Lady-day, to make his fallows and prepare the wheat lands for the ensuing crop. He pays for hay at a fodder price, and for seed, labour, and sowing of grass seeds, but not for rent and taxes on the fallows, which are all paid in full by the outgoing tenant to the end of his term.

Buckinghamshire.—The incoming tenant pays for labour, seed, and sowing, but not for dung.

Cambridgeshire.—The incoming tenant pays for all kind of

labour, seed, and sowing, but not for dung. He also takes to straw and chaff at a fodder price. There is however a custom by which the incoming tenant thrashes and draws to market the corn of the last year's growth, receiving in return the straw and chaff as remuneration.

Cheshire.—The incoming tenant pays for seed, labour, and sowing, but not for dung.

Cornwall.—The incoming tenant pays rent and taxes for the fallow land, as in Surrey, but generally has the option of pre-entry. The dung upon the premises is not paid for.

Cumberland.—The incoming tenant at Candlemas-day pays for seed, sowing, and labour of every description, as well as a proportionate sum of the year's rent and rates on the fallows.

Derbyshire.—The incoming tenant to a farm in this county pays for very much the same tillages as in Surrey; viz., for full fallows and full dressings, the value of the labour and manure expended for seed and sowing, and a year's rent and rates.

For half fallows and half dressings on those lands from which only one crop has been taken subsequently to the fallow, at the value of half the labour on such fallows, half the value of the manure, and a half-year's rent and rates. But with reference to seeds that may have been sown on the half fallow and failed, the custom of Derbyshire differs from that of Surrey, inasmuch as the outgoing and incoming tenant are made to share the loss in equal moieties. Where the seeds do not fail, seed and sowing is valued in full. Hay and straw is taken at market price.

Devonshire.—The incoming tenant has a right of pre-entry to prepare the wheat lands on a Michaelmas tenancy, and the lands for spring crops of a Lady-day tenancy. In the latter tenancy, he pays for the wheat crop at valuation. Nothing is paid for manure, hay, and straw.

Dorsetshire.—The very simple custom of quitting a farm in the same manner as the tenant entered appears to be the most general.

Durham.—The incoming tenant generally has the right of pre-entry to fallows, and the use of the unexpended manure arising out of the last year's crop. Pays for seeds and sowing, and for the after feed.

Essex.—The incoming tenant pays for labour and manure upon the fallows, seeds, and sowing, and for dung in the yards.

Gloucestershire.—The incoming tenant has generally a right of pre-entry, and is entitled to the dung arising from the last year's crop.

Herefordshire.—The incoming tenant has a right of pre-entry,

and to the manure from the last year's crop, but pays for seeds sown.

Hertfordshire.—The right of pre-entry to work fallows exists pretty generally. The incoming tenant is entitled to one-fifth of the land for fallow, and one-fifth upon which he can sow grass seeds.

Hampshire.—The incoming tenant pays for labour upon the fallows, and for carting and spreading dung; but is entitled to the dung without payment.

Huntingdonshire.—The incoming tenant pays for labour upon the fallows, but is entitled to the dung free of cost.

Kent.—The incoming tenant pays for fallows and half fallows, dressings and half dressings, seed and sowing, clover leys, underwood down to the stub, manure upon the premises, and hay and straw of the last year's growth at a fodder price.

Lancashire.—The outgoing tenant is paid (usually speaking) for wheat sowing, and is bound generally to leave the farm in the same state as he found it.

Leicestershire.—The incoming tenant pays for labour, and the year's rent and rates upon the fallows. For seed, sowing, and full dressings.

Lincolnshire.—The incoming tenant has the right of pre-entry; pays for clover and grass seeds, and for carting manure, but is entitled to the dung free of cost.

Middlesex.—In this county there is a great breadth of land under culture as market gardens and meadows, to which special agreements generally apply. On the arable lands the incoming tenant at Michaelmas generally pays for fallows, half fallows, dressings, half dressings, clover leys, hay, straw, and dung. There are very few woods and coppices, but where one is met with the underwood is taken to according to its growth.

Norfolk.—The incoming tenant pays for the crop of seeds and turnips, and for clover leys, but not for dung. He has to draw to market within reasonable distance the outgoing tenant's corn from the last year's crop, in return for which he gets the straw and chaff.

Northamptonshire.—The incoming tenant pays for fallows, seeds sown, and labour, but not for manure.

Northumberland.—The right of pre-entry allows an incoming tenant to make his fallows, sow clover and grass seeds, and cart out the dung of the last year's crop, to which he is entitled. The holdings generally expire at Lady-day, but the outgoing tenant is entitled to the crops of the last year; the carting and stacking of

which is done by the incoming tenant, who in return is entitled to the straw when thrashed.

Nottinghamshire.—The incoming tenant pays for fallows, labour, seed, and sowing, and to a limited extent for unexhausted improvements.

Oxfordshire.—The incoming tenant pays for labour on fallows, seeds, and sowing, and for hay of the last year at a fodder price, but not for dung.

Rutlandshire.—The incoming tenant pays for labour on the fallows, and for carting the dung. If a Lady-day tenancy, he also pays for wheat crop, turnips, and seeds, for winter ploughing; and if the spring corn, is sown for seeds, sowing, and labour.

Shropshire.—The incoming tenant pre-enters on the farm. Pays for the wheat crop and clover seeds upon the land, if they have not been previously fed off, and for the dung and unconsumed hay and straw of the last year's growth. (This custom assumes a Lady-day entry.)

Somersetshire.—The tenancy generally commences at Christmas or Lady Day. The incoming tenant pays for the crop of wheat, or for labour, seed, and sowing, for clover seeds and sowing, sometimes for dung, and generally for hay and straw at fodder price.

Staffordshire.—The incoming tenant at Lady-day pays for what in this county is called pin-following, but what in Surrey would be termed a bastard fallow, and for hay and straw at fodder price, which here is two-thirds of the market price of the former, and one-third of the latter. The custom leaves the dung on the farm for the use of the incoming tenant, but it is equally the custom of this county that what a tenant pays for when he enters, he is to be paid for when he leaves. The custom as to the wheat crop is very undefined.

Suffolk.—The incoming tenant at Michaelmas pays for all the labour on the fallows, the seeds sown, and labour attending them, and for the dung and hay. He is required to draw out the outgoing tenant's corn, and in return gets all the straw and chaff of the last year's crop free.

Surrey.—The county of Surrey is notorious for its high valuations. The tenancies, although frequently entered upon at other times, are generally computed as from Michaelmas. The valuation comprises fallows, half fallows, dressings, half dressings, grass seeds, underwood, clover leys, hay, straw, and manure upon the premises.

Under the heading of "Fallows" are included all the ploughings, harrowings, rollings, and couchings, whether judicious or unneces-

sary, that the fallow can be shown to have received at the hands of the outgoing tenant, a year's rent and rates, and if sown with turnips, the seed and sowing. Half fallows are generally charged at an agreed sum by the valuators, without going into the details of the previous fallow. They are said to arise, as has been previously explained, on lands that have only borne one straw crop since the full fallow.

Dressings are charged at the full value of the dung, in addition to the cost of carting and spreading. Half dressings arise in the same way as half fallows, and are generally treated similarly by the valuers. Clover seeds are charged at the cost of seed and labour. Clover leys at their estimated value. Underwoods according to their growth. Hay and straw sometimes at a fodder price, and sometimes at a market price; and dung at its measured value.

In those cases that the occupancy commences at a period of winter or spring, the incoming tenant is charged with the costs of all the labour, seed and sowing, rates and taxes, that have been expended upon the farm since the previous Michaelmas (from which date his rent commences,) in addition to the valuation to which he would have been subject had he entered at Michaelmas. When the occupation commences in summer, the incoming tenant generally takes to the standing crops at a valuation, and the outgoing clears up the rent to the following Michaelmas, excepting such parts thereof as are taken into account in the valuation of the fallows. It is an essential feature in the custom of Surrey that a tenant is entitled to be paid on leaving for all such things as he paid for when he entered.

The general tenure of Surrey may be said to be leases of 7, 14, or 21 years, the middle term prevailing. The rentals are almost without exception half-yearly payments in money. The landlord generally finds timber rough upon the stem, and bricks, tiles, and lime at a kiln within seven miles, for the repairs, the tenant finding cartage and labour. In most cases the restrictions as to cultivation direct that one-fourth of the arable lands must be in wheat or beans; one-fourth fallow and turnips; one-fourth barley or oats; and one-fourth seeds.

I have gone more fully into the customs of this county because they are familiar to me, and because it will in some measure tend to illustrate my interpretation of certain technical expressions made use of by me which bear a different meaning in different counties. To take but one instance, I understand a "Dressing" to be a quantity of manure bestowed on the land; whereas I believe in many parts of England the word "dressing" is applied to one course

of ploughing, harrowing, &c., and it is very common to say that a fallow has five dressings.

Sussex.—Those portions of the county that adjoin Kent and Surrey have very similar customs to those of the adjoining counties. In other parts the labour upon the fallows is charged, but not the rent and rates. The dung arising out of the crop of the last two years of the tenancy belongs to the incoming tenant, the only charge upon it being for carting, casting into heaps, turning, and spreading. The incoming tenant sometimes carts to market the corn of the last year's growth belonging to his predecessor, taking in return the straw and chaff. When this carting is not done, the straw and chaff is paid for at fodder price.

Warwickshire.—The incoming tenant at Lady-day generally pays for seed, sowing, rent, and rates on the wheat crop from Michaelmas; but a custom prevails allowing the outgoing tenant to retain possession of the wheat lands *that are after fallow*, not otherwise, until the following Michaelmas, to get in his wheat crop, in which case he pays the new occupier the half-year's rent and rates. The custom as to spring crops allows no right of pre-entry to the incoming tenant; if the outgoing occupier prepares and sows the land, he is paid for so doing at valuation. No fallows are paid for in this county; but if the turnip crop fails on fallowed land, the outgoer is allowed one half-year's rent and rates thereon in consideration of the labour he has expended. The dung is not paid for.

Westmoreland.—The incoming tenant pays for seed, sowing, and labour, previously expended, and a portion of the rent and rates of fallows. (The expressions *waygoing* and *oncoming* are substituted in the North for *outgoing* and *incoming* in the South.)

Wiltshire.—The incoming tenant has the right of pre-entry, to make his fallows and sow his wheat, turnips, and grass seeds. He is entitled to the dung arising from the crops of the last two years, and the outgoing tenant consumes the fodder.

Worcestershire.—The chief feature in the custom appears to be, that a tenant leaves a farm on the same conditions as he entered upon it.

Yorkshire, East Riding of.—The incoming tenant at Lady-day is entitled to pre-entry at Candlemas to plough lands for fallow. He has to pay for clover seeds and sowing, and for the manure arising from the last year's crop. He also pays for the growing crops of corn at a valuation, made at suitable times near harvest. The payments for the amount of the growing crops are (in some cases I am aware, but whether generally so I am not fully informed) allowed to be made by instalments, as the corn is thrashed, so that a

smaller capital is required to take to a farm under this custom than is at first sight apparent.

Yorkshire, North Riding of.—The same right of pre-entry exists as in the East Riding from Candlemas-day, the tenancy commencing at Lady-day. The incoming tenant pays for clover seed and sowing of the preceding year, and for the manure from the last year's crop. He also pays for the wheat crop at valuation at harvest, or allows the outgoing tenant to harvest the crop.

Yorkshire, West Riding of.—The tenancy commences at Lady-day, the tenant having a right of pre-entry at Candlemas. Fallows and half fallows, dressings and half dressings, are valued in this Riding in some instances. The wheat crop is sometimes harvested by the outgoing tenant; sometimes the incoming occupier pays for it at valuation; and clover leys are paid for.

I have now gone through the whole of the customs in force in the several counties of England, so far as they relate to, or form the subject of, valuations of tenant-right, and as well as I have been enabled to gather information. It will be obvious to every practical man that the customs of many counties are exceedingly difficult to define, varying as they frequently do in different parishes of the same county, and especially is this the case with reference to the periods of entry. My endeavour has been to place together such an amount of information as will convey a general idea of the whole question; the information is of necessity imperfect, but at the same time it affords a key to the principal features.

The following specimen of a Surrey Valuation will sufficiently elucidate the principle of making them, and writing out the inventory.

Before commencing a valuation, the valuators should always appoint in writing an umpire, to whom matters of difference may be referred. If this is not attended to, difficulties sometimes arise at a subsequent stage in the choice of an umpire, causing great delay and trouble.

SPECIMEN OF FIELD BOOK.

Quantity in each Field.	Name of Field.	Quantity in each Course.	Items of Valuation.	Price per Acre.	Value of Labour and Tillages.	Value of Dressings.	Amount of Rent and Rates.	Total Value.	Value of each Field.
A. R. P.		A. R. P.			£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.
42 2 0	**Garson.** *Fallow.* Rotation of Crops, 1849 ½ Wheat, ½ Fallow; 1850 Tares fed Fallow; 1851 Wheat; 1852 Fallow	40 0 0	5 times Ploughed.	@10/	100 0 0				
			2 tine Dragged ...	„1/4	5 6 8				
			Once Rolled (with 4 horses)	„1/6	3 0 0				
								108 6 8	
		20 0 0	Dunged 12 Cart Loads per Acre						
			Carting and Spreading ...	„80/		80 0 0		80 0 0	
		40 0 0	Rent and Rates ..	„35/			70 0 0	70 0 0	
									258 6 8
20 0 0	**Barn Field.** *Fallow.* Rotation of Crops, 1849 Wheat; 1850 Tares fed Fallow; 1851 Wheat; 1852 Fallow	20 0 0	5 times Ploughed.	„11/	55 0 0				
			2 tine Dragged ..	„1/6	3 0 0				
			Once Rolled (with 4 horses)	„1/6	1 10 0				
								59 10 0	
			Dunged 12 Cart Loads per Acre						
			Carting and Spreading ...	„80/		80 0 0		80 0 0	
			Rent and Rates ..	„35/			35 0 0	35 0 0	
									174 10 0

34 1 6	**Guildford Field.**	33 0 0									
	Seeds		7 lbs. of Clover Seed, per acre	@ 6d.	5 15 6						
	Rotation of Crops, 1849 Wheat 1850 Beans 1851 Fallow, Swedes 1852 Wheat, Oats.		7 lbs. of Trefoil per acre . . .	„ 4d.	3 17 0						
			2 tine small Harrowing. .	„ 6d.	1 13 0						
	Seeds.		Once Rolling . .	„ 6d.	0 16 6						
			Half Fallow . . .	„ 40s.	66 0 0						
									78 2 0		
		18 0 0	Half Dressing. .	„ 40s.			36 0 0		36 0 0		
20 3 16	**Twenty Acres.**	20 0 0	Twice Ploughed.	„ 12s.	24 0 0				24 0 0		114 2 0
	Rotation of Crops, 1849 Wheat 1850 Clover 1851 Oats 1852 Peas.										24 0 0
20 2 16	**Long Field.**	20 0 0	The Ley	„ 45s.	45 0 0				45 0 0		
	Clover Ley		Half Dressing. .	„ 35s.			35 0 0		35 0 0		
	Rotation of Crops, 1849 Tares and Swedes										80 0 0
	1850 Peas 1851 Wheat 1852 Clover.										
8 0 30	**Common Field.**	8 0 0	Half Fallow. . .	„ 40s.	16 0 0				16 0 0		16 0 0
	Rotation of Crops, 1849 Clover Ley 1850 Oats 1851 Tares fed Fallow 1852 Wheat.										

29 1 6	**Pond Field.** Rotation of Cropping, 1849 Clover Ley 1850 Wheat 1851 Peas Fallow 1852 Wheat.	28 0 0	Half Dressing. . .	@ 40s.		56 0 0		56 0 0	56 0 0
29 3 10	**Carthouse Field.** *Seeds* Rotation of Cropping, 1849 Beans 1850 Wheat 1851 Swedes, Mangold, Tares 1852 Wheat Seeds.	28 0 0	Two tine small Harrowing.	„ 6d.	1 8 0				
			Once Rolling . . .	„ 6d.	14 0				
			200lbs of Clover Seed	„ 6d.	5 0 0				
			10 Bushels of Rye Grass	„ 6s.	3 0 0				
								10 2 0	
		20 0 0	Half Dressings . .	„ 40s.		40 0 0		40 0 0	
		20 0 0	Half Fallow	„ 40s.	40 0 0			40 0 0	90 2 0
35 2 8	**Cross Path Field.** Rotation of Cropping, 1849 Peas Fallow 1850 Wheat 1851 Winter Beans 1852 Tares fed, Tares cut, Fallow.	34 0 0	Twice Ploughed .	„ 13s.	44 4 0			44 4 0	
		16 0 0	* Rent and Rates .	„ 30s.			24 0 0	24 0 0	68 4 0

* The Rent and Rates is allowed on that portion of the Field from which the Tares were fed. This has been decided by very competent judges as being the Surrey custom. I cannot discover the equity of it. The Tenant should surely pay the Rent of Land upon which he has kept a flock of Sheep

SUMMARY.

Quantity in each Field.			Name of Field.	Quantity in each Course.			Items of Valuation.	Price.	Value of Labour and Tillages.			Value of Dressings.			Amount of Rent and Rates.			Total Value.			Value of each Field.		
A.	R.	P.		A.	R.	P.			L.	S.	D.	L.	S.	D.	L.	S.	D.	L.	S.	D.	L.	S.	D.
42	2	0	Garson	40	0	0	Fallow		108	6	8	80	0	0	70	0	0				258	6	8
20	0	0	Barn Field	20	0	0	Fallow		59	10	0	80	0	0	35	0	0				174	10	0
34	1	6	Guildford Field .	33	0	0	Seeds		78	2	0	36	0	0							114	2	0
20	3	16	Twenty Acres . .	20	0	0	Ploughed after Peas		24	0	0										24	0	0
20	2	16	Long Field	20	0	0	Clover Ley		45	0	0	35	0	0							80	0	0
8	0	30	Common Field. . .	8	0	0	Wheat Ersh		16	0	0										16	0	0
29	1	6	Pond Field	28	0	0	Wheat Ersh					56	0	0							56	0	0
29	3	10	Carthouse Field . .	28	0	0	Seeds		50	2	0	40	0	0							90	2	0
35	2	8	Crosspath Field .	34	0	0	Fallow		44	4	0				24	0	0				68	4	0
241	0	12		231	0	0			425	4	8	327	0	0	129	0	0				881	4	8
			A Hill of Dung, 33 yards by 10 yards, and 2 feet high, at 5s. per yard																		55	0	0
			A Rick of Clover Hay, 10 yards by 6 yards, and 4 yards high, at £4 10s. per load																		162	0	0
			Three Years' growth in about 3 acres of Underwood																		6	6	0
																				£	1104	10	8

EDWARD RYDE,
JAMES SMITH, } *Valuators.*

With reference to the preceding form of Field Book, little need be said. It will be found convenient in general use, although perhaps few valuers will adopt it, simply because it appears to cause extra trouble; such, however, is not the case, and the information it affords is very interesting. The first column sets forth the actual quantity of the field, including waste and hedge and ditch: the outside measure thereof, properly speaking. The second column contains the name of the field, under which is written the cultivation, and in the same column there is always room to make a memorandum of the rotation of cropping, which should be enquired into. The third column sets forth the inside measure of the field, or the different quantities included in one course of husbandry. The fourth column contains the different items of the valuation. The fifth is set apart for the price. The sixth, seventh, and eighth contain respectively the amounts of different charges, distinguishing those for dressings and half dressings, and the allowance for rent and rates from the valuation of the tillages and labour. The ninth is a column for the totals of the three preceding columns and for any extraneous matters that cannot be ranged under either of the other heads. The tenth and last column contains the total amount of valuation in each field in a convenient form for casting.

In writing out the inventory the prices are not given.

The following is the manner in which this is done:—

An INVENTORY and VALUATION of tillages and tenant-right upon a farm in Surrey, as made between Mr. Daniel Longstaff and Mr. Richard Smith, this 25th day of October, 1852, by Edward Ryde, on the part of the said Daniel Longstaff, and James Smith, on the part of the said Richard Smith.

A.	R.	P.	
42	2	0	**Garson**—*Fallow*
			40 0 0—5 times ploughing
			2 tine dragging
			Once rolling
			20 0 0 Dunging, carting & spreading
			40 0 0 Rent and rates.
20	0	0	**Barn Field**—*Fallow*
			5 times ploughing
			2 tine dragging
			Once rolling
			Dunging, carting & spreading
			Rent and rates.

A.	R.	P.			
34	1	6	**Guildford Field**—*Seeds*		
			33	0	0 Clover seed and sowing
					2 tine small harrowing
					Once rolling
					Half fallow
			18	0	0 Half dressing.
20	3	16	**The Twenty Acres**		
			20	0	0 Twice ploughing.
20	2	16	**Long Field**—*Clover Ley*		
			20	0	0 The ley
					Half dressing.
8	0	30	**Common Field**—*Wheat Ersh*		
			8	0	0 Half fallow.
29	1	6	**Pond Field**—*Wheat Ersh*		
			28	0	0 Half dressing.
29	3	10	**Carthouse Field**—*Seeds*		
			28	0	0—2 tine small harrowing
					Once rolling
					Clover seed and sowing
			20	0	0 Half dressing
					Half fallow.
35	2	8	**Cross Path Field**—*Fallow*		
			34	0	0—Twice ploughed
			16	0	0 Rent and rates
					A hill of dung
					A rick of clover hay
3	0	0	**Wood**—3 *Years' growth of underwood.*		

The tillages, and other acts of husbandry, matters and things mentioned in the foregoing inventory, are valued at the sum of one thousand, one hundred and four pounds, ten shillings and eight pence, by us,

EDWARD RYDE,
JAMES SMITH.

In connection with this subject the following directions and **Tables for Measuring Hay Ricks** will be useful.

Let fig. 173[a] represent a hay stack, the content of which is required:—

It will be obvious that the mean length, width, and height, taken at the places indicated on this fig., are the correct dimensions for ascertaining the proper cubic content of the stack.

The density of the stack must then be estimated, and the remaining operations are supplied by the tables.

Table 1.

To be used when the Hay is very close.

Feet wide.	6 feet high.	7 feet high.	8 feet high.	9 feet high.	10 feet high.	11 feet high.	12 feet high.	13 feet high.	14 feet high.	Feet wide.
6	72	84	96	108	120	132	144	156	168	6
7	84	98	112	126	140	154	168	182	196	7
8	96	112	128	144	160	176	192	208	224	8
9	**108**	**126**	**144**	**162**	**180**	**198**	**216**	**234**	**252**	**9**
10	120	140	160	180	200	220	240	260	280	10
11	132	154	176	198	220	242	264	286	308	11
12	144	168	192	216	240	264	288	312	336	12
13	**156**	**182**	**208**	**234**	**260**	**286**	**312**	**338**	**364**	**13**
14	168	196	224	252	280	308	336	364	392	14
15	180	210	240	270	300	330	360	390	420	15
16	192	224	256	288	320	352	384	416	448	16
17	**204**	**238**	**272**	**306**	**340**	**374**	**408**	**442**	**476**	**17**
18	216	252	288	324	360	396	432	468	504	18
19	228	266	304	342	380	418	456	494	532	19
20	240	280	320	360	400	440	480	520	560	20
21	**252**	**294**	**336**	**378**	**420**	**462**	**504**	**546**	**588**	**21**
22	264	308	352	396	440	484	528	572	616	22
23	276	322	368	414	460	506	552	598	644	23
24	288	336	384	432	480	528	576	624	672	24
25	**300**	**350**	**400**	**450**	**500**	**550**	**600**	**650**	**700**	**25**
26	312	364	416	468	520	572	624	676	728	26
27	324	378	432	486	540	594	648	702	756	27

EXAMPLE. Required the Content of a Hay Stack 23 feet long, 16 feet wide, and 10 feet high; the Hay being *very close*

In Table 1, opposite 16 feet wide, and under 10 feet high, stands the number 320, which is carried to Table 4, to complete the calculation.

Note. A very little practice will show which of the Tables, 1, 2, or 3, should be made use of for different description of Ricks, as, for example, suppose a person were to measure a Rick and estimate the content by Table 2, which when cut out proved to contain more Hay than the Tables gave him, he would know in future, that that description of Rick must be measured by Table 1, or if it contained less, then would he know that Table 3 must in future be used; and, having acquainted himself with the kind of Rick adapted for the two extremes, the mean, or Table 2, will of course follow.

Table 2.

To be used when the Hay is of a mean density.

Feet wide.	6 feet high.	7 feet high.	8 feet high.	9 feet high.	10 feet high.	11 feet high.	12 feet high.	13 feet high.	14 feet high.	Feet wide.
6	60	70	80	90	100	110	120	130	140	6
7	70	81	93	105	116	128	140	151	163	7
8	80	93	106	120	133	146	160	173	186	8
9	**90**	**105**	**120**	**135**	**150**	**165**	**180**	**195**	**210**	**9**
10	100	116	133	150	166	183	200	216	233	10
11	110	128	146	165	183	201	220	238	256	11
12	120	140	160	180	200	220	240	260	280	12
13	**130**	**151**	**173**	**195**	**216**	**238**	**260**	**281**	**303**	**13**
14	140	163	186	210	233	256	280	303	326	14
15	150	175	200	225	250	275	300	325	350	15
16	160	186	213	240	266	293	320	346	373	16
17	**170**	**198**	**226**	**255**	**283**	**311**	**340**	**368**	**396**	**17**
18	180	210	240	270	300	330	360	390	420	18
19	190	221	253	285	316	348	380	411	443	19
20	200	233	266	300	333	366	400	433	466	20
21	**210**	**245**	**280**	**315**	**350**	**385**	**420**	**455**	**490**	**21**
22	220	256	293	330	366	403	440	476	513	22
23	230	268	306	345	383	421	460	498	536	23
24	240	280	320	360	400	440	480	520	560	24
25	**250**	**291**	**333**	**375**	**416**	**458**	**500**	**541**	**583**	**25**
26	260	303	346	390	433	476	520	563	606	26
27	270	315	360	405	450	495	540	585	630	27

EXAMPLE Suppose a Hay Stack, 33 feet long. 18 feet wide, and 12 feet high, and the Hay of a mean density, what does it contain?

In Table 2, under 12 feet high, and opposite 18 feet wide, stands the Number 360, which must be carried to Table 4, to complete the calculation.

Table 3.

To be used when the Hay is very loose.

Feet wide.	6 Feet high.	7 Feet high.	8 Feet high.	9 Feet high.	10 Feet high.	11 Feet high.	12 Feet high.	13 Feet high.	14 Feet high.	Feet wide.
6	51	60	68	77	85	94	102	111	120	6
7	60	70	80	90	100	110	120	130	140	7
8	68	80	91	102	114	125	137	148	160	8
9	77	90	102	115	128	141	154	167	180	9
10	**85**	**100**	**114**	**128**	**142**	**157**	**171**	**185**	**200**	**10**
11	94	110	125	141	157	172	188	204	220	11
12	102	120	137	154	171	188	205	222	240	12
13	111	130	148	167	185	204	222	241	260	13
14	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	**14**
15	128	150	171	192	214	235	257	278	300	15
16	137	160	182	205	228	251	274	297	320	16
17	145	170	194	218	242	267	291	315	340	17
18	**154**	**180**	**205**	**231**	**257**	**282**	**308**	**334**	**360**	**18**
19	162	190	217	244	271	298	325	352	380	19
20	171	200	228	257	285	314	342	371	400	20
21	180	210	240	270	300	330	360	390	420	21
22	**188**	**220**	**251**	**282**	**314**	**345**	**377**	**408**	**440**	**22**
23	197	230	262	295	328	361	394	427	460	23
24	205	240	274	308	342	377	411	445	480	24
25	214	250	285	321	357	392	428	464	500	25
26	**222**	**260**	**297**	**334**	**371**	**408**	**445**	**482**	**520**	**26**
27	231	270	308	347	385	424	462	501	540	27

EXAMPLE.—Suppose a Hay Rick 40 feet long, 18 feet wide, and 12 feet high, the Hay *very loose*, what are its contents?

In Table 3, under 12 feet high, and opposite 18 feet wide, stands the number 308, which carried to Table 4, will complete the calculation.

Table 4. Completing the Calculations and showing the Content of Ricks, in Trusses.

Numbers.	15 ft. long.	16 ft. long.	17 ft. long.	18 ft. long.	19 ft. long.	20 ft. long.	Numbers.	21 ft. long.	22 ft. long.	23 ft. long.	24 ft. long.	25 ft. long.	26 ft. long.
	Trusses.	Trusses.	Trusses.	Trusses.	Trusses.	Trusses.		Trusses.	Trusses.	Trusses.	Trusses.	Trusses.	Trusses.
1	1	1	1	1	1	2	1	2	2	2	2	2	2
2	3	3	3	3	3	4	2	4	4	4	4	5	5
3	4	4	5	5	5	6	3	6	6	6	7	7	7
4	6	6	6	7	7	8	4	8	8	9	9	10	10
5	**7**	**8**	**8**	**9**	**9**	**10**	**5**	**10**	**11**	**11**	**12**	**12**	**13**
6	9	9	10	10	11	12	6	12	13	13	14	15	15
7	10	11	11	12	13	14	7	14	15	16	16	17	18
8	12	12	13	14	15	16	8	16	17	18	19	20	20
9	13	14	15	16	17	18	9	18	19	20	21	22	23
10	**15**	**16**	**17**	**18**	**19**	**20**	**10**	**21**	**22**	**23**	**24**	**25**	**26**
20	30	32	34	36	38	40	20	42	44	46	48	50	52
30	45	48	51	54	57	60	30	63	66	69	72	75	78
40	60	64	68	72	76	80	40	84	88	92	96	100	104
50	**75**	**80**	**85**	**90**	**95**	**100**	**50**	**105**	**110**	**115**	**120**	**125**	**130**
60	90	96	102	108	114	120	60	126	132	138	144	150	156
70	105	112	119	126	133	140	70	147	154	161	168	175	182
80	120	128	136	144	152	160	80	168	176	184	192	200	208
90	135	144	153	162	171	180	90	189	198	207	216	225	234
100	**150**	**160**	**170**	**180**	**190**	**200**	**100**	**210**	**220**	**230**	**240**	**250**	**260**
200	300	320	340	360	380	400	200	420	440	460	480	500	520
300	450	480	510	540	570	600	300	630	660	690	720	750	780
400	600	640	680	720	760	800	400	840	880	920	960	1000	1040
500	**750**	**800**	**850**	**900**	**950**	**1000**	**500**	**1050**	**1100**	**1150**	**1200**	**1250**	**1300**
600	900	960	1020	1080	1140	1200	600	1260	1320	1380	1440	1500	1560
700	1050	1120	1190	1260	1330	1400	700	1470	1540	1610	1680	1750	1820

EXAMPLE. In Example to Table 1 our calculation was held in abeyance after finding the number 320.

Now by this Table, under 23 feet long, opposite 300 stands 690 Trusses.

" 20 " 46 "

320 content. 736 "

Table 4 *continued.* Showing the Content of Ricks, in Trusses.

Numbers.	27 ft. long.	28 ft. long.	29 ft. long.	30 ft. long.	31 ft. long.	32 ft. long.	Numbers.	33 ft. long.	34 ft. long.	35 ft. long.	36 ft. long.	37 ft. long.	38 ft. long
	Trusses.	Trusses.	Trusses	Trusses.	Trusses.	Trusses.		Trusses.	Trusses.	Trusses.	Trusses.	Trusses.	Trusses.
1	2	2	2	3	3	3	1	3	3	3	3	3	3
2	5	5	5	6	6	6	2	6	6	7	7	7	7
3	8	8	8	9	9	9	3	9	10	10	10	11	11
4	10	11	11	12	12	12	4	13	13	14	14	14	15
5	**13**	**14**	**14**	**15**	**15**	**16**	**5**	**16**	**17**	**17**	**18**	**18**	**19**
6	16	16	17	18	18	19	6	19	20	21	21	22	22
7	18	19	20	21	21	22	7	23	23	24	25	25	26
8	21	22	23	24	24	25	8	26	27	28	28	29	30
9	24	25	26	27	27	28	9	29	30	31	32	33	34
10	**27**	**28**	**29**	**30**	**31**	**32**	**10**	**33**	**34**	**35**	**36**	**37**	**38**
20	54	56	58	60	62	64	20	66	68	70	72	74	76
30	81	84	87	90	93	96	30	99	102	105	108	111	114
40	108	112	116	120	124	128	40	132	136	140	144	148	152
50	**135**	**140**	**145**	**150**	**155**	**160**	**50**	**165**	**170**	**175**	**180**	**185**	**190**
60	162	168	174	180	186	192	60	198	204	210	216	222	228
70	189	196	203	210	217	224	70	231	238	245	252	259	266
80	216	224	232	240	248	256	80	264	272	280	288	296	304
90	243	252	261	270	279	288	90	297	306	315	324	333	342
100	**270**	**280**	**290**	**300**	**310**	**320**	**100**	**330**	**340**	**350**	**360**	**370**	**380**
200	540	560	580	600	620	640	200	660	680	700	720	740	760
300	810	840	870	900	930	960	300	990	1020	1050	1080	1110	1140
400	1080	1120	1160	1200	1240	1280	400	1320	1360	1400	1440	1480	1520
500	**1350**	**1400**	**1450**	**1500**	**1550**	**1600**	**500**	**1650**	**1700**	**1750**	**1800**	**1850**	**1900**
600	1620	1680	1740	1800	1860	1920	600	1980	2040	2100	2160	2220	2280
700	1890	1960	2030	2100	2170	2240	700	2310	2380	2450	2520	2590	2660

EXAMPLE. In Table 2 our calculation was held in abeyance after finding the number 360. In Table 4, under 33 feet long, opposite 300 stands 990 Trusses.

60 „ 198 „

360 content. 1188 „

Note.—This calculation, containing two lines of figures, may appear unnecessarily troublesome at first sight, but on inspection, it will be obvious that the figures might have been taken from the Table, and cast together mentally, without the slightest effort.

Table 4 *continued.* Showing the Content of Ricks, in Trusses.

Numbers.	39 ft. long. Trusses.	40 ft. long. Trusses.	41 ft. long. Trusses.	42 ft. long. Trusses.	43 ft. long. Trusses.	44 ft. long. Trusses.	Numbers.	45 ft. long. Trusses.	46 ft. long. Trusses.	47 ft. long. Trusses.	48 ft. long. Trusses.	49 ft. long. Trusses.	50 ft. long. Trusses.
1	3	4	4	4	4	4	1	4	4	4	4	4	5
2	7	8	8	8	8	8	2	9	9	9	9	9	10
3	11	12	12	12	12	13	3	13	13	14	14	14	15
4	15	16	16	16	17	17	4	18	18	18	19	19	20
5	**19**	**20**	**20**	**21**	**21**	**22**	**5**	**22**	**23**	**23**	**24**	**24**	**25**
6	23	24	24	25	25	26	6	27	27	28	28	29	30
7	27	28	28	29	30	30	7	31	32	32	33	34	35
8	31	32	32	33	34	35	8	36	36	37	38	39	40
9	35	36	36	37	38	39	9	40	41	42	43	44	45
10	**39**	**40**	**41**	**42**	**43**	**44**	**10**	**45**	**46**	**47**	**48**	**49**	**50**
20	78	80	82	84	86	88	20	90	92	94	96	98	100
30	117	120	123	126	129	132	30	135	138	141	144	147	150
40	156	160	164	168	172	176	40	180	184	188	192	196	200
50	**195**	**200**	**205**	**210**	**215**	**220**	**50**	**225**	**230**	**235**	**240**	**245**	**250**
60	234	240	246	252	258	264	60	270	276	282	288	294	300
70	273	280	287	294	301	308	70	315	322	329	336	343	350
80	312	320	328	336	344	352	80	360	368	376	384	392	400
90	351	360	369	378	387	396	90	405	414	423	432	441	450
100	**390**	**400**	**410**	**420**	**430**	**440**	**100**	**450**	**460**	**470**	**480**	**490**	**500**
200	780	800	820	840	860	880	200	900	920	940	960	980	1000
300	1170	1200	1230	1260	1290	1320	300	1350	1380	1410	1440	1470	1500
400	1560	1600	1640	1680	1720	1760	400	1800	1840	1880	1920	1960	2000
500	**1950**	**2000**	**2050**	**2100**	**2150**	**2200**	**500**	**2250**	**2300**	**2350**	**2400**	**2450**	**2500**
600	2340	2400	2460	2520	2580	2640	600	2700	2760	2820	2880	2940	3000
700	2730	2800	2870	2940	3010	3080	700	3150	3220	3290	3360	3430	3500

EXAMPLE By Table 3 our calculation remained in abeyance after finding the number 308. In Table 4, under 40 feet long, opposite 300 stands 1200 Trusses.

8 ,, 32 ,,

308 content. 1232 ,,

Note.—The Contents are given in Trusses on account of the different custom of calculating by the Load of 36 Trusses in some counties, and by the Ton of 40 Trusses in others.

Table 5.

Showing the number of loads and tons which are contained in any number of trusses.

Trusses.	Loads. Trusses.	Tons. Trusses.	Trusses.	Loads. Trusses.	Tons. Trusses.	Trusses.	Loads. Trusses.	Tons. Trusses.	Trusses.	Loads. Trusses.	Tons. Trusses.
36	1 0	0 36	270	7 18	6 30	504	14 0	12 24	756	21 0	18 36
40	1 4	1 0	280	7 28	7 0	510	14 6	12 30	760	21 4	19 0
50	1 14	1 10	288	8 0	7 8	520	14 16	13 0	792	22 0	19 32
60	**1 24**	**1 20**	**290**	**8 2**	**7 10**	**530**	**14 26**	**13 10**	**800**	**22 8**	**20 0**
70	1 34	1 30	300	8 12	7 20	540	15 0	13 20	828	23 0	20 28
72	2 0	1 32	310	8 22	7 30	550	15 10	13 30	840	23 12	21 0
80	2 8	2 0	320	8 32	8 0	560	15 20	14 0	864	24 0	21 24
90	**2 18**	**2 10**	**324**	**9 0**	**8 4**	**570**	**15 30**	**14 10**	**880**	**24 16**	**22 0**
100	2 28	2 20	330	9 6	8 10	576	16 0	14 16	900	25 0	22 20
108	3 0	2 28	340	9 16	8 20	580	16 4	14 20	920	25 20	23 0
110	3 2	2 30	350	9 26	8 30	590	16 14	14 30	936	26 0	23 16
120	**3 12**	**3 0**	**360**	**10 0**	**9 0**	**600**	**16 24**	**15 0**	**960**	**26 24**	**24 0**
130	3 22	3 10	370	10 10	9 10	610	16 34	15 10	972	27 0	24 12
140	3 32	3 20	380	10 20	9 20	612	17 0	15 12	1000	27 28	25 0
144	4 0	3 24	390	10 30	9 30	620	17 8	15 20	1100	30 20	27 20
150	**4 6**	**3 30**	**396**	**11 0**	**9 36**	**630**	**17 18**	**15 30**	**1200**	**33 12**	**30 0**
160	4 16	4 0	400	11 4	10 0	640	17 28	16 0	1300	36 4	32 20
170	4 26	4 10	410	11 14	10 10	648	18 0	16 8	1400	38 32	35 0
180	5 0	4 20	420	11 24	10 20	650	18 2	16 10	1500	41 24	37 20
190	**5 10**	**4 30**	**430**	**11 34**	**10 30**	**660**	**18 12**	**16 20**	**1600**	**44 16**	**40 0**
200	5 20	5 0	432	12 0	10 32	670	18 22	16 30	1700	47 8	42 20
210	5 30	5 10	440	12 8	11 0	680	18 32	17 0	1800	50 0	45 0
216	6 0	5 16	450	12 18	11 10	684	19 0	17 4	1900	52 28	47 20
220	**6 4**	**5 20**	**460**	**12 28**	**11 20**	**690**	**19 6**	**17 10**	**2000**	**55 20**	**50 0**
230	6 14	5 30	468	13 0	11 28	700	19 16	17 20	2500	69 16	62 20
240	6 24	6 0	470	13 2	11 30	710	19 26	17 30	3000	83 12	75 0
250	6 34	6 10	480	13 12	12 0	720	20 0	18 0	3500	97 8	87 20
252	**7 0**	**6 12**	**490**	**13 22**	**12 10**	**730**	**20 10**	**18 10**	**4000**	**111 4**	**100 0**
260	7 8	6 20	500	13 32	12 20	740	20 20	18 20	5000	138 32	125 0

EXAMPLE 1. In 1800 trusses, how many loads or tons?
Opposite 1800 trusses stands 50 loads or 45 tons.

EXAMPLE 2. In 736 trusses, how many loads?
Opposite 730 stands 20 loads, 10 trusses, to which if we mentally add 6 trusses, we get the required answer.

EXAMPLE 3. In 736 trusses, how many tons?
Opposite 730 stands 18 tons 10 trusses, to which if we mentally add the remaining 6 trusses, we get the required answer.

Table 6. Showing the Value of any Number of Trusses at various prices per Truss, Load, or Ton.

Trusses.	2s. Per Truss, £3 12s. 0d. Per Load, £4 0s. 0d. Per Ton.			2s. 1d. Per Truss, £3 15s. 0d. Per Load, £4 3s. 4d. Per Ton.			2s 2d. Per Truss, £3 18s. 0d. Per Load, £4 6s. 8d. Per Ton.			Trusses.	2s. 3d. Per Truss, £4 1s. 0d. Per Load, £4 10s. 0d. Per Ton.			2s. 4d. Per Truss, £4 4s. 0d. Per Load, £4 13s. 4d. Per Ton.			2s. 5d. Per Truss, £4 7s. 0d. Per Load, £4 16s. 8d. Per Ton.			Trusses.	2s. 6d. Per Truss, £4 10s. 0d. Per Load, £5 0s. 0d. Per Ton.			2s. 7d. Per Truss, £4 13s. 0d. Per Load, £5 3s. 4d. Per Ton.			2s. 8d. Per Truss, £4 16s. 0d. Per Load, £5 6s. 8d. Per Ton.		
	£	s.	d.	£	s.	d.	£	s.	d.		£	s.	d.	£	s.	d.	£	s.	d.		£	s.	d.	£	s.	d.	£	s.	d.
5	0	10	0	0	10	5	0	10	10	5	0	11	3	0	11	8	0	12	1	5	0	12	6	0	12	11	0	13	4
10	1	0	0	1	0	10	1	1	8	10	1	2	6	1	3	4	1	4	2	10	1	5	0	1	5	10	1	6	8
20	2	0	0	2	1	8	2	3	4	20	2	5	0	2	6	8	2	8	4	20	2	10	0	2	11	8	2	13	4
30	3	0	0	3	2	6	3	5	0	30	3	7	6	3	10	0	3	12	6	30	3	15	0	3	17	6	4	0	0
40	**4**	0	**0**	**4**	**3**	**4**	**4**	**6**	**8**	**40**	**4**	**10**	**0**	**4**	**13**	**4**	**4**	**16**	**8**	**40**	**5**	**0**	**0**	**5**	**3**	**4**	**5**	**6**	**8**
50	5	0	0	5	4	2	5	8	4	50	5	12	6	5	16	8	6	0	10	50	6	5	0	6	9	2	6	13	4
60	6	0	0	6	5	0	6	10	0	60	6	15	0	7	0	0	7	5	0	60	7	10	0	7	15	0	8	0	0
70	7	0	0	7	5	10	7	11	8	70	7	17	6	8	3	4	8	9	2	70	8	15	0	9	0	10	9	6	8
80	8	0	0	8	6	8	8	13	4	80	9	0	0	9	6	8	9	13	4	80	10	0	0	10	6	8	10	13	4
90	**9**	**0**	**0**	**9**	**7**	**6**	**9**	**15**	**0**	**90**	**10**	**2**	**6**	**10**	**10**	**0**	**10**	**17**	**6**	**90**	**11**	**5**	**0**	**11**	**12**	**6**	**12**	**0**	**0**
100	10	0	0	10	8	4	10	16	8	100	11	5	0	11	13	4	12	1	8	100	12	10	0	12	18	4	13	6	8
200	20	0	0	20	16	8	21	13	4	200	22	10	0	23	6	8	24	3	4	200	25	0	0	25	16	8	26	13	4
300	30	0	0	31	5	0	32	10	0	300	33	15	0	35	0	0	36	5	0	300	37	10	0	38	15	0	40	0	0
400	40	0	0	41	13	4	43	6	8	400	45	0	0	46	13	4	48	6	8	400	50	0	0	51	13	4	53	6	8
500	**50**	**0**	**0**	**52**	**1**	**8**	**54**	**3**	**4**	**500**	**56**	**5**	**0**	**58**	**6**	**8**	**60**	**8**	**4**	**500**	**62**	**10**	**0**	**64**	**11**	**8**	**66**	**13**	**4**
600	60	0	0	62	10	0	65	0	0	600	67	10	0	70	0	0	72	10	0	600	75	0	0	77	10	0	80	0	0
700	70	0	0	72	18	4	75	16	8	700	78	15	0	81	13	4	84	11	8	700	87	10	0	90	8	4	93	6	8
800	80	0	0	83	6	8	86	13	4	800	90	0	0	93	6	8	96	13	4	800	100	0	0	103	6	8	106	13	4
900	**90**	**0**	**0**	**93**	**15**	**0**	**97**	**10**	**0**	**900**	**101**	**5**	**0**	**105**	**0**	**0**	**108**	**15**	**0**	**900**	**112**	**10**	**0**	**116**	**5**	**0**	**120**	**0**	**0**
1000	100	0	0	104	3	4	108	6	8	1000	112	10	0	116	13	4	120	16	8	1000	125	0	0	129	3	4	133	6	8
2000	200	0	0	208	6	8	216	13	4	2000	225	0	0	233	6	8	241	13	4	2000	250	0	0	258	6	8	266	13	4
3000	300	0	0	312	10	0	325	0	0	3000	337	10	0	350	0	0	362	10	0	3000	375	0	0	387	10	0	400	0	0
4000	**400**	**0**	**0**	**416**	**13**	**4**	**433**	**6**	**8**	**4000**	**450**	**0**	**0**	**466**	**13**	**4**	**483**	**6**	**8**	**4000**	**500**	**0**	**0**	**516**	**13**	**4**	**533**	**6**	**8**

EXAMPLE. What is the value of 666 Trusses of Hay at four guineas per Load?

Under £4 4s. per Load, opposite	600	stands	. .	£70	0 0
,,	60	,,	. .	7	0 0
,,	5	,,	. .	0	11 8
and	1	is	. .	0	2 4
	666			£77	14 0

Note.—Here again Trusses have been used as the measure of quantity given, that it might serve equally whether Tons or Loads are the customary measure. Most of the calculations may be made mentally, or at all events with very little addition.

Table 6 *continued.*—Showing the Value of any Number of Trusses at various prices per Truss, Load, or Ton.

Trusses.	2s 9d, Per Truss, £4 19s. 0d. Per Load, £5 10s. 0d. Per Ton.			2s. 10d. Per Truss, £5 2s. 0d. Per Load, £5 13s. 4d. Per Ton.			2s. 11d. Per Truss, £5 5s. 0d Per Load, £5 16s. 8d. Per Ton.			Trusses.	3s. Per Truss, £5 8s. 0d. Per Load, £6 0s. 0d. Per Ton.			3s. 1d. Per Truss. £5 11s. 0d. Per Load, £6 3s. 4d. Per Ton.			3s. 2d. Per Truss, £5 14s. 0d. Per Load, £6 6s. 8d. Per Ton.			Trusses.	3s. 3d. Per Truss, £5 17s. 0d. Per Load, £6 10s 0d Per Ton.			3s. 4d. Per Truss, £6 0s. 0d. Per Load, £6 13s 4d. Per Ton.			3s. 6d. Per Truss. £6 6s 0d. Per Load, £7 0s. 0d. Per Ton.		
	£	s.	d.	£	s.	d.	£	s.	d.		£	s.	d.	£	s.	d.	£	s.	d.		£	s.	d.	£	s.	d.	£	s.	d.
5	0	13	9	0	14	2	0	14	7	5	0	15	0	0	15	5	0	15	10	5	0	16	3	0	16	8	0	17	6
10	1	7	6	1	8	4	1	9	2	10	1	10	0	1	10	10	1	11	8	10	1	12	6	1	13	4	1	15	0
20	2	15	0	2	16	0	2	18	4	20	3	0	0	3	1	8	3	3	4	20	3	5	0	3	6	8	3	10	0
30	4	2	6	4	5	8	4	7	6	30	4	10	0	4	12	6	4	15	0	30	4	17	6	5	0	0	5	5	0
40	**5**	**10**	**0**	**5**	**13**	**4**	**5**	**16**	**8**	**40**	**6**	**0**	**0**	**6**	**3**	**4**	**6**	**6**	**8**	**40**	**6**	**10**	**0**	**6**	**13**	**4**	**7**	**0**	**0**
50	6	17	6	7	1	8	7	5	10	50	7	10	0	7	14	2	7	18	4	50	8	2	6	8	6	8	8	15	0
60	8	5	0	8	10	0	8	15	0	60	9	0	0	9	5	0	9	10	0	60	9	15	0	10	0	0	10	10	0
70	9	12	6	9	18	4	10	4	2	70	10	10	0	10	15	10	11	1	8	70	11	7	6	11	13	4	12	5	0
80	11	0	0	11	6	8	11	13	4	80	12	0	0	12	6	8	12	13	4	80	13	0	0	13	6	8	14	0	0
90	**12**	**7**	**6**	**12**	**15**	**0**	**13**	**2**	**6**	**90**	**13**	**10**	**0**	**13**	**17**	**6**	**14**	**5**	**0**	**90**	**14**	**12**	**6**	**15**	**0**	**0**	**15**	**15**	**0**
100	13	15	0	14	13	4	14	11	8	100	15	0	0	15	8	4	15	16	8	100	16	5	0	16	13	4	17	10	0
200	27	10	0	28	6	8	29	3	4	200	30	0	0	30	16	8	31	13	4	200	32	10	0	33	6	8	35	0	0
300	41	5	0	42	10	0	43	15	0	300	45	0	0	46	5	0	47	10	0	300	48	15	0	50	0	0	52	10	0
400	55	0	0	56	13	4	58	6	8	400	60	0	0	61	13	4	63	6	8	400	65	0	0	66	13	4	70	0	0
500	**68**	**15**	**0**	**70**	**16**	**8**	**72**	**18**	**4**	**500**	**75**	**0**	**0**	**77**	**1**	**8**	**79**	**3**	**4**	**500**	**81**	**5**	**0**	**83**	**6**	**8**	**87**	**10**	**0**
600	82	10	0	85	0	0	87	10	0	600	90	0	0	92	10	0	95	0	0	600	97	10	0	100	0	0	105	0	0
700	96	5	0	99	3	4	102	1	8	700	105	0	0	107	18	4	110	16	8	700	113	15	0	116	13	4	122	10	0
800	110	0	0	113	6	8	116	13	4	800	120	0	0	123	6	8	126	13	4	800	130	0	0	133	6	8	140	0	0
900	**123**	**15**	**0**	**127**	**10**	**0**	**131**	**5**	**0**	**900**	**135**	**0**	**0**	**138**	**15**	**0**	**142**	**10**	**0**	**900**	**146**	**5**	**0**	**150**	**0**	**0**	**157**	**10**	**0**
1000	137	10	0	141	13	4	145	16	8	1000	150	0	0	154	3	4	158	6	8	1000	162	10	0	166	13	4	175	0	0
2000	275	0	0	283	6	8	291	13	4	2000	300	0	0	308	6	8	316	13	4	2000	325	0	0	333	6	8	350	0	0
3000	412	10	0	425	0	0	437	10	0	3000	450	0	0	462	10	0	475	0	0	3000	487	10	0	500	0	0	525	0	0
4000	**550**	**0**	**0**	**566**	**13**	**4**	**583**	**6**	**8**	**4000**	**600**	**0**	**0**	**616**	**13**	**4**	**633**	**6**	**8**	**4000**	**650**	**0**	**0**	**666**	**13**	**4**	**700**	**0**	**0**

EXAMPLE. What is the value of 3660 Trusses at £5 10s. per Ton?

Opposite	3000	trusses is	£412	10 0
,,	600	,,	82	10 0
,,	60	,,	8	5 0
	3660		£503	5 0

CHAPTER XIX.

VALUATION OF PARISHES.

In addition to what has been adduced in previous chapters, a very brief description of the principles that govern Parish Valuations, made for the purposes of Poor Law Assessment, will be sufficient.

The words of the "Parochial Assessment Act" are—that no rate for the relief of the poor in England and Wales shall be allowed by any justices, or be of any force, which shall not be made upon an estimate of the *net* annual value of the several hereditaments rated thereto, that is to say, the *rent* at which the same might be reasonably expected to let from year to year, free of all usual rates and taxes, and tithe commutation rent charge, (if any,) and deducting therefrom the probable average annual cost of repairs, insurance, and other expences (if any,) necessary to maintain them in a state to command such rent.

The instructions issued by the Poor-Law Commissioners with reference to this particular clause in the Act, run as follow :—

The column headed "Gross Estimated Rental," must be filled up with the estimated value of the holding, calculated on an estimate of what would be a reasonable rent to pay from year to year, if there were no tenant's rates and taxes, no tithe, or commutation rent charge, no repairs to be done by the tenant, nor insurance, nor other expences to be incurred by him as necessary to keep the property in its present condition.

The column headed "Rateable Value," must be filled up thus :—From the gross rental, ascertained as above, must be deducted the estimate amount of tenant rates and taxes, of tithe commutation rent charge, (if any,) of repairs and insurance, and of any other expences necessary to keep the property in its present condition.

The residue will be the "Rateable Value," or "Net Annual Value," according to the first section of the "Parochial Assessment Act."

Now, with reference to the words of the Act, it is quite obvious that the *rent* alluded to is not intended to be the *rent* actually paid by the tenant, but the rent the property is fairly worth, in comparison with other properties in the same parish, and comprised in the same assessment.

The correct basis of all parish valuations must evidently be equality and fairness; therefore, it is not possible to make the

amount of rent that any individual tenant may chance to pay for his holding the foundation of any calculation for the assessment of that holding. Yet this is by no means an unusual manner of viewing the matter. Men say a thing is worth what it will fetch. If a farm or a house is not worth the money that is given for it, how has the tenant been found who will undertake to pay that which he cannot afford. They urge it is strong presumptive evidence of the value of the properties, and therefore, as such, the rent so paid, should be the amount at which the property should be assessed.

A landed proprietor, of considerable intelligence, in a parish I once surveyed, told me he should have made a better valuation than I did, for he could have access to the returns of the rentals made for the Income Tax, at which amounts he would have assessed all properties that were tenanted, and would have valued those only that were in hand.

I will not go beyond this very parish to refute the arguments thus adduced. Take the case of one of the farms, which we will call A. The land is in a high state of cultivation, and is good in quality. The homestead and residence are above the average character. Previous to the present tenancy it was farmed by the proprietor, who let it without a great portion of the incoming valuation, that is to say, there were so many acres of fallow upon the farm, for which the tenant did not pay; he is to leave the same number on quitting the same, with half fallows, dressings, and half dressings. The dung arising out of the last year's crops was left upon the premises for the use of the tenant, and is to be left in like manner when he quits. Now a farm so taken to, is in a position to, and did, command a high rent.

Take an opposite case. A farm we will call B. The incoming present tenant found no stable nor cow-house upon the premises, and the landlord too poor to build one. The tenant undertook to do it, and it cost him £400. He also paid £800 for the incoming valuation. Now this tenant of course has a lease for 21 years, but then look what deduction must be made in his rent on account of his outlay.

To take the valuation sum of £800, first: I have already shown in the proper place that a tenant should get something like 10 per cent. for capital thus locked up, so that £800 amounts to £80 a year. We must next assume that he puts by about £15 per annum to a sinking fund, to accumulate at compound interest at 5 per cent., to replace at the end of the term the capital expended upon the buildings, upon which he is also entitled to 10 per cent. interest, so that a further sum of £40 arises under this head.

To review the question, suppose each farm to be worth £600 per annum, while the tenant of farm A pays this rent to his landlord, the tenant of B deducts the three sums of £80, £15, and £40, and pays his landlord £465.

The following is a tabular view of the case.

	Yearly Rent paid by Tenant.	Amount of Assessment as estimated at the fair yearly value of each Farm.
	£	£
Farm A.	600	600
„ B.	465	600

If these farms were assessed on their rental, A would pay towards a rate, at 1*s.* in the pound, £30; while B would pay but £23 5*s.*, notwithstanding the two farms are of equal value.

Such is the comparison with respect to farms and lands; now take one as to houses.

Take a row of three houses, all of equal value but belonging to separate proprietors.

A takes No. 1, which the landlord has placed in good repair, and undertakes so to maintain it. The rent under these circumstances is £50 per annum.

B takes No. 2, which the landlord has also placed in good repair, but the tenant is to do future repairs and to insure. The rent under such circumstances is £44 a-year.

C takes No. 3, which is sadly out of repair, and the landlord too poor to do what is necessary. The tenant undertakes to do the repairs, and to maintain them afterwards, as well as to pay the insurance. The rent under such circumstances is £37.

According to the principle of assessing properties at the rent paid for them—

	£	*s.*	*d.*
A would pay for No. 1, to a rate at 1*s.* in the pound .	2	10	0
B „ for No. 2, „ „ „ .	2	4	0
C „ for No. 3, „ „ „ .	1	17	0

an arrangement manifestly unfair, unequal, and incorrect.

I am aware it may be objected to what I have said, that tenants do not get sufficient allowance made in their rent, under circumstances such as I have enumerated; but to this I would reply, that it is quite a matter of personal moment to themselves only. If they are not sufficiently acquainted with business of this nature to

make an equitable arrangement, there are at all times plenty of competent professional men, who, for a very small fee, would furnish all the information that is required.

I therefore submit, that in construing the Parochial Assessment Act, the word rent must always be understood to imply such a yearly sum as a property may be fairly estimated to be worth in comparison with other property in the same parish.

To pass to the instructions of the Poor Law Commissioners, as to filling up the column headed Gross Estimated Rental, and I must repeat the instructions.

"The column headed Gross Estimated Rental must be filled up with the gross estimated value of the holding, calculated on an estimate of what would be a reasonable rent to pay from year to year, if there were no tenant's rates and taxes, no tithe or commutation rent charge, no repairs to be done by the tenant, nor insurance, nor other expenses to be incurred by him as necessary to keep the property in its present condition."

It will be obvious, that to fill up the column in this way, the fair rental of a farm must first be computed in the manner shown in a previous chapter, to which must be added the amount of the poor rates, church, highway, and other rates, now paid by the tenant, because if there were none of these imposts, all tenants would be able to pay a higher rent than they now pay by just the amount of these outgoings.

These instructions were adopted by many valuers, myself among others, in about one instance to each valuer; but it was never repeated. The gross value so obtained represented such entirely fictitious sums, that the greatest dissatisfaction among the ratepayers resulted; and notwithstanding the additions were all taken off again before the rateable value was entered, the thing appeared so grossly inconsistent, that the poor valuer was assumed to know very little of his profession, if his motives were not characterized by a harder term.

The practice is, to place in the column of Gross Rental, the sum at which the property has been valued, and to deduct therefrom an amount for repairs, insurance on the buildings, and the tithe or commutation rent charge (if any) for the net rental.

It has been suggested that an allowance should be made for the repairs of the gates, roads, and fences on a farm; but the practical difficulties that arise, render futile any attempt to do so. To adopt the principle fairly, a greater allowance must be made on small fields than on large ones; and it could never be a per centage deduction from the amount of the valuation, inasmuch as a gate costs

as much to repair, if it belongs to land not worth 10*s.* an acre, as one that belongs to land of four times the value. Moreover, in the valuation of single fields, it would become necessary to ascertain exactly the length of fence belonging to each field, (for some fields are bounded entirely by fences belonging to the adjoining fields,) and whether there is a gate or not.

In entering upon the valuation of a parish, considerable care is necessary in arriving at a proper standard of value, which should not be too high; but having determined upon the standard, all the remainder is easily accomplished by comparison.

The principles enunciated in the chapter on the Valuation of Estates, will apply in the Valuation of Parishes; so that they need not be again referred to; but a few brief remarks upon the rating of railways, gas and water companies, will not be out of place.

If we take the case of a railway, it will serve for the water or gas companies without further illustration.

A railway, like a farm, cannot be valued on its cost of construction, since cost is not the measure of value. It is the yearly sum it is worth to a tenant by way of rent that can alone form the subject of calculation as to its value.

The first amount to be ascertained is the sum of the annual earnings, which will answer to the item of *produce* on a farm. From this has to be deducted, first, the cost of working the line, including all outgoings, which is the same thing as the cost of cultivation on a farm; secondly, the sum for renewing the rolling stock or plant; thirdly, the interest due to the tenant on the value of his rolling stock; fourthly, a sum for superintendence and management; and the remainder is rent, at which the railway should be assessed.

The cost of construction clearly having nothing to do with the yearly value of the railway, nor the sum at which it should be assessed.

There is one item which should possibly be considered in the case of a railway; an extra allowance for casualties, over which a tenant may not be able to exercise control; but great caution must be used in admitting to what extent railway accidents are beyond control. It is exceedingly likely that if the great lines of railway were in the occupation of tenants to whom responsibility individually attached, some of the accidents that have occurred would have been avoided, even if we suppose the present managers to be the tenants. For there are, doubtless, many things now sanctioned by managers and boards of directors, of which they cannot approve, but to which they are partly coerced by their

desire to retain the satisfaction of the shareholders, who care very little about anything beyond a large dividend.

It is not at all likely that a railway will be situated entirely in one parish, hence comes the necessity of dividing the rate, and fairly apportioning it among the several parishes. Some valuators have argued that this should be done by an equal mileage rate, because say they, inasmuch as no money is taken in some parishes, while large sums are taken in others, an average is all that can be arrived at. Others there are who say that those parishes in which no money is taken, cannot possibly lay claim to any rate, as the earnings there are nothing; or at any rate, they say, you must either assess them on an estimate of the cost of constructing the line, or of the original value of the land. This is all very fallacious, which there is small difficulty in proving.

We must never lose sight of the fact that the railway is liable to be rated at what it is worth to rent. Now, to estimate this rent suppose the portion of the line that is situate in each parish to be held by a separate tenant; of course in such a case all the expenses must be borne by a *pro-rata* mileage charge, and all the tenants must equitably divide the allowance for superintendence and management. To look at the case of the tenant in the parish in which no station is situate; what is his position? He cannot take any money of the public; but would not he take care that if the other tenants took money of the public in other parishes, for travelling over his portion of the line, they should, if he allowed them so to travel, pay him his share of such earnings; and therefore his portion of the line would become as well worth a rent as any of the others, upon which rent he should be assessed, and thus explode the erroneous principles to which I have alluded.

The method of apportioning the rent of a railway among the several parishes for the purposes of assessment has been much discussed, and is, as I believe, very little understood. Notwithstanding it is very simple and clearly demonstrable.

The working expenses I am prepared to admit may be spread equally over the whole railway according to the earnings, (except in cases of long lines that are worked in distinct sections, and in such cases each section may be considered as a separate line,) the allowance for wear and tear or renewal of the rolling stock may also be so; the interest on tenants' capital should be made to follow the same proportion as the allowance for the renewal of the rolling stock; and the allowance for superintendence should be evidently greater on those parts of the line where the earnings are large, than where they are small.

It is with the division of the earnings or value of the produce of the railway among the several parishes, I have mostly to deal in this place. To illustrate this clearly we must draw a Plan. Fig. 173 *m*.

Without any reference to scale we will assume, that, from the terminus at A, there is in the parish No. 1, 5 miles; and that from terminus A to station B is seven miles, so that two miles of that length is in parish No. 2.

From B to C we will take to be 5 miles, of which 1 mile is in parish No. 2, 3 miles in parish No. 3, and 1 mile in parish No. 4. From C to D we have 2 miles—1 mile in parish No. 4, and 1 mile in parish No. 5. From D to E is 6 miles, of which 1 mile is in parish No. 5, and 5 miles in parish No. 6.

The most convenient mode will be to tabulate the details, and the results will become apparent.

Names of Stations.	Whole Length.		Parish No. 1.		Parish No. 2.		Parish No. 3.		Parish No. 4.		Parish No. 5.		Parish No. 6.	
	Total Length of Line.	Total Earnings.	Length of Line.	Apportioned Earnings.	Length of Line.	Apportioned Earnings.	Length of Line.	Apportioned Earnings.	Length of Line.	Apportioned Earnings.	Length of Line.	Apportioned Earnings.	Length of Line.	Apportioned Earnings.
	Miles.	£	Miles.	£	Miles.	£	Miles.	£	Miles.	£	Miles.	£	Miles.	£
A to B	7	21000	5	15000	2	6000								
—— C	12	42000	5	17500	3	10500	3	10500	1	3500				
—— D	14	56000	5	20000	3	12000	3	12000	2	8000	1	4000		
—— E	20	80000	5	20000	3	12000	3	12000	2	8000	2	8000	6	20000
B to A	**7**	**21000**	**5**	**15000**	**2**	**6000**								
—— C	5	15000	—	—	1	3000	3	9000	1	3000				
—— D	7	14000	—	—	1	2000	3	6000	2	4000	1	2000		
—— E	13	32500	—	—	1	2500	3	7500	2	5000	2	5000	5	12500
C to A	**12**	**36000**	**5**	**15000**	**3**	**9000**	**3**	**9000**	**1**	**3000**				
—— B	5	5000	—	—	1	1000	3	3000	1	1000				
—— D	2	3000	—	—	—	—	—	—	1	1500	1	1500		
—— E	8	16000	—	—	—	—	—	—	1	2000	2	4000	5	10000
D to A	**14**	**49000**	**5**	**17500**	**3**	**10500**	**3**	**10500**	**2**	**7000**	**1**	**3500**		
—— B	7	14000	—	—	1	2000	3	6000	2	4000	1	2000		
—— C	2	3000	—	—	—	—	—	—	1	1500	1	1500		
—— E	6	12000	—	—	—	—	—	—	—	—	1	2000	5	10000
E to A	**20**	**70000**	**5**	**17500**	**3**	**10500**	**3**	**10500**	**2**	**7000**	**2**	**7000**	**5**	**17500**
—— B	13	26000	—	—	1	2000	3	6000	2	4000	2	4000	5	10000
—— C	8	12000	—	—	—	—	—	—	1	1500	2	3000	5	7500
—— D	6	12000	—	—	—	—	—	—	—	—	1	2000	5	10000
		539500	5	137500		89000		102000		64000		49500		97500

The preceding Table clearly shows the earnings between each separate station and also in each parish. The following table shows the fallacy of taking a general average of the receipts to guide the valuation of a separate parish; it being quite evident that, if the length of line in each of these parishes were let to a separate tenant, the length in parish No. 3, would be worth infinitely more rent than that in parish No. 6:—

Parish.	No. of Miles.	Gross Earnings.	Earnings per Mile.	
		£		
No. 1	5	137,500	27,500	
„ 2	3	89,000	29,666.6	
„ 3	3	102,000	34,000	
„ 4	2	64,000	32,000	
„ 5	2	49,500	24,750	
„ 6	5	97,500	19,500	
Total	20	539,500	26,975	General Average.

Union valuations have been spoken of for the purpose of equalising assessments.

The real fact is that there should be one universal assessment throughout England and Wales entrusted to the central authority of one competent surveyor, who should select some 500 or 1000 acres of arable and meadow land, and in the most careful manner estimate its value according to its productiveness. The average price of corn upon which this estimate is based should be preserved, as a standard for regulating the valuation at any future time when higher or lower prices might prevail. The object of valuing these 1000 acres would be to afford a test to the ideas of the several valuators who might be engaged in the work, and as a means whereby uniformity might be attained. Every valuer, upon completing the valuation of a parish or district, should proceed to the valuation of the 1000 acres. If his value of it is in excess of the standard estimate, the valuation he has previously made must be reduced accordingly. This will be found (it is suggested), a very sound way of securing equality of rating, far preferable to any other. Most valuers have impressed upon their minds a certain scale of prices for all kinds of lands, and it is of little use to show them any other standard whether higher or lower: for if the doing so influences them at all, it only has the effect of causing them to commit irregularities of which they would not otherwise have been guilty by causing them to put some fields higher or lower as the case may be, while others they assess at their own standard.

SPECIMEN of the Mode of WRITING OUT the VALUATION

1	2	3	4			5			6			7		
Name or Situation of each Field or Parcel of Property.	Description or Mode of Cultivation of each Field or Parcel of Property.	No. on Map (if there be any.)	Quantity of each Field or Parcel of Property.			Total Quantity in each Holding which is separately Rated.			Gross Estimated Rental of each Holding which is separately Rated.			Rateable Value of each Holding which is separately Rated.		
			A.	R.	P.	A	R.	P.	£	s.	d.	£	s.	d.
Barn Field	Arable .	16	9	2	16									
Long Field	Arable .	19	10	2	1									
Little Mead	Grass . .	25	1	3	11									
Great Mead	Grass . .	26	19	2	10									
Garson	Arable .	27	31	3	1									
Oxted Field	Arable .	28	29	0	6									
Barn and Yard . . .		29	0	0	30									
Cottage and Garden		30	0	1	0									
						102	2	35	150	0	0	140	0	0
Lane End Field . .	Arable .	31	53	2	16									
Upper Down	Arable .	32	19	1	10									
Middle Down	Arable .	33	22	3	10									
Lower Down	Arable .	34	23	1	10									
Drove Lane		35	1	1	12									
Barn and Yard . . .		36	0	1	20									
						120	2	38	180	0	0	175	0	0
Stable Mead	Grass . .	131	5	1	10									
Orchard	Grass . .	132	1	1	20									
Lawn Pasture	Grass . .	133	3	1	10									
House and Garden .		134	0	3	20									
						10	3	20	70	0	0	55	0	0

in the Form Prescribed by the Poor Law Commissioners.

8	9	10	11	
Name or Situation of each Holding which is separately Rated.	Description of each Holding which is separately Rated.	Name of Occupier of each Holding which is separately Rated.	No. in Rate Book.	Name of Owner of each Holding which is separately Rated.
Bunker's Hill	Farm and Lands	Smith, John		Carlow, Earl of
Down Farm	Down Land	Smith, John		Derry, William
Manor House	House and Land	Smith, John		Himself

SPECIMEN OF FIELD BOOK,

Occupier, **Higgins, James**

No. on Plan.	Name of Field.	State of Cultivation.	Quantity. A.	R.	P.	Price per Acre.
16	Barn Field	Arable	5	3	30	30*s.*
17	Furze Brook	Grass	2	3	19	12*s.* 6*d.*
18	Long Mead	Grass	5	2	0	30*s.*
23	Hazle Field	Arable	4	2	6	25*s.*
24	Pond Field	Arable	2	1	16	18*s.*
25	Loampit Field	Arable	5	1	30	25*s.*
26	Common Field	Arable	5	2	10	27*s.* 6*d.*
27	Quarry Field	Arable	9	1	16	25*s.*
28	Station Field	Arable	10	2	13	22*s.* 6*d.*
29	Windmill Hill	Grass	5	3	30	25*s.*
30	Garson	Arable	9	2	18	22*s.* 6*d.*
36	Length Furlong	Arable	10	1	13	27*s.* 6*d.*
38	First Home Mead	Grass	2	3	16	40*s.*
39	Second Home Mead	Grass	5	1	13	40*s.*
40	Large Home Mead	Grass	11	2	15	42*s.* 6*d.*
41	The Vineyard	Grass	15	3	30	42*s.* 6*d.*
42	Cherry Orchard	Grass	10	2	9	45*s.*
44	Oxford	Grass	15	3	1	40*s.*
45	Lock's Farm	Homestead...	1	3	10	
		House & Garden	0	1	10	
	Allotment Field	Arable	48	1	10	32*s.* 6*d.*
			190	2	5	

Deduct for Tithe, Insurance, and

With reference to the form of Valuation, it is necessary to observe that the three owners, three valuations are required to be stated.

recommended for a **PARISH VALUATION.**

Owner, **Long, John**

Value.			Gross Rental.			Rateable Value.			Remarks.
£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	
8	18	1							
1	15	10							Rushy and poor.
8	5	0							
5	13	6							
2	2	6							Unhandy; wet.
6	16	0							
7	13	0							
11	13	9							
11	18	0							Gravelly on brow.
7	8	5							
10	16	3							
14	4	0							
5	14	0							
10	13	3							
24	12	9							
33	17	4							
23	17	10							
31	10	3							Burns.
25	0	0							
78	10	1							⅓ 35/; ⅓ 32/6; ⅓ 30/
330	19	10	331	0	0	280	0	0	
Repairs			51	0	0				

value of each separate holding must be given. So that, if one occupier hold of

CHAPTER XX.

BUILDERS' PRICES.

SECT. I.—*Carpenters' and Joiners' Prices.*

ROOFS,

At per square of 100 *feet superficial.*

	Labour.		Nails.	
	s.	*d.*	*s.*	*d.*
Common shed roofs, one story high	3	3	1	0
The same, with purlins	4	0	1	6
If two stories, add	0	6	0	0
If three stories, add	1	0	0	0
Common span or valley, with purlins and rafters, two stories high	5	0	2	0
If three stories, add	0	6	0	0
Framed roofs, with collars, dove-tailed into sides of rafters, notched to receive purlins, and filled in with common rafters	9	6	3	6
Roofs framed, with principals, king posts, purlins, braces, and common rafters	13	5	4	0
The same, with kings and queens	15	9	4	0
Common curb roofs on one side	5	7	2	6
If two sides, add	0	6	0	0
If three sides, add	1	0	0	0
If above two stories, add	0	6	0	0

The timber to be measured and taken at per foot cube.

NAKED FLOORS,

At per square.

	Labour.		Nails.	
Ceiling floors, joists only	2	11	1	6
The same, framed with tie beams	4	2	1	9
The same, with binding and ceiling joists	5	0	1	11
Ground joists bedded, but not framed	2	6	1	6
The same, pinned down on plates, and framed to chimnies	4	2	1	6
Single-framed floors, trimmed to chimnies and stairs	5	3	1	9
If above 9 inches deep	7	10	0	0
Framed with girders and cased bays	8	6	3	0
Framed with girders, binding, bridging, and ceiling joists	12	6	4	0

QUARTER PARTITIONS,

At per square.

	Labour.		Nails.	
	s.	*d.*	*s.*	*d.*
Common 4 inch braced partitions	4	6	1	3
Do. 5 inch do.	5	3	1	6
Do. 6 inch do.	5	6	1	6
Truss-framed with king posts	8	8	1	6
Do. with king and queen posts	10	0	0	0

If oak, extra one-third.

LABOUR ON FIR TIMBER,

At per foot cube.

Cube fir bond*	0	4
Do. framed	0	8
Do. truss framed	0	10
Do. framed and chamfered	0	10
Do. wrought and framed	1	1
Do. wrought, framed, and rebated	1	3
Do. wrought, framed, rebated, and beaded	1	6
Do. wrought, framed, rebated, and double beaded	1	8
Do. proper door cases	1	11
Planing fir per foot superficial	0	1

LABOUR ON DEALS,

At per foot superficial.

For deals from ½ in. to 1½ in. thick—				
,, ,,	edges shot	0	0	½
,, ,,	plugged	0	0	½
,, ,,	jacked	0	0	½
,, ,,	rounded	0	0	½
,, ,,	planing on each side	0	1	
,, ,,	grooved	0	1	
,, ,,	rebated	0	1	
,, ,,	ploughed and tongued	0	1	
,, ,,	framed	0	1	
,, ,,	battened	0	1	
,, ,,	mitred	0	1	
,, ,,	scribed	0	1	
,, ,,	backed	0	1	
,, ,,	throated	0	1	
,, ,,	clamped	0	1	
,, ,,	beaded	0	1	

* Bond timbers, wall plates, wood bricks, pole and curb, &c., are all to be under the head of bond.

	Labour.		Nails.	
	s.	*d.*	*s.*	*d.*
For deals from ½ in. to 1½ in. thick—				
,, ,, cut circular	0	1½		
,, ,, cut standards	0	2¼		
,, ,, sunk shelves	0	2¼		
,, ,, scolloped	0	2¼		
,, ,, ledged	0	2¼		
,, ,, dovetailed	0	2¼		
For deals from 2 to 3 in. thick—				
,, ,, edges shot	0	1		
,, ,, plugged	0	1		
,, ,, jacked	0	1		
,, ,, rounded	0	1		
,, ,, planing on each side	0	1½		
,, ,, grooved	0	1½		
,, ,, rebated	0	1½		
,, ,, ploughed and tongued	0	1½		
,, ,, framed	0	1½		
,, ,, battened	0	1½		
,, ,, mitred	0	1½		
,, ,, scribed	0	1½		
,, ,, backed	0	1½		
,, ,, throated	0	1½		
,, ,, clamped	0	1½		
,, ,, beaded	0	1½		
,, ,, cut circular	0	2¼		
,, ,, cut standards	0	3		
,, ,, sunk shelves	0	3		
,, ,, scolloped	0	3		
,, ,, ledged	0	3		
,, ,, dovetailed	0	3		

BATTENING TO WALLS,

At per square.

¾ in. to 1¼ in., 12 in. from centre to centre	3	0	2	0
If plugged to walls, add	0	10	1	0
Wall hooks add extra	0	0	0	0

WEATHER BOARDING,

At per square.

Rough	2	1	2	0
,, splayed edges	3	5	2	0
Wrought	5	0	2	0
Wrought and beaded	6	3	2	0

ROUGH BOARDING,

		Labour.		Nails.	
	At per square.	*s.*	*d.*	*s.*	*d.*
¾ inch deal,	rough	2	6	1	6
„	edges shot	3	4	1	6
„	ploughed and tongued	3	9	1	6
Inch deal,	rough	2	9	2	0
„	edges shot	3	6	2	0
„	ploughed and tongued	4	7	2	0
Whole deal,	rough	2	11	3	0
„	edges shot	3	9	3	0
„	ploughed and tongued	5	2	3	0
1½ in. deal,	rough	3	4	3	6
„	edges shot	4	4	3	6
„	ploughed and tongued	5	10	3	6

DEAL FLOORS,

	At per square.				
Inch deal,	rough edges shot	3	10	1	6
„	wrought, folding	5	11	1	6
„	straight joint	7	6	1	6
Whole deal,	rough edges shot	4	3	2	0
„	wrought folding	6	3	2	0
„	wrought straight joint, splayed headings	8	10	3	0
„	do. do. dowelled	15	10	4	0
1½ inch deal,	rough edges shot	4	7	2	6
„	wrought folding	6	8	2	6
„	wrought straight joint, splayed heading	10	0	3	0
„	if ploughed and tongued headings, add	1	6	0	0
„	if ploughed and tongued edges, add	2	7	0	0
„	for tongues to edges of boards, add	4	2	0	0

BATTEN FLOORS,

At per square.				
Inch wrought folding	7	6	2	6
Inch wrought, straight joint, splayed headings	9	0	2	6
Inch and quarter wrought folding	8	4	2	6
Inch and quarter straight joint, splayed headings	10	10	3	6
The same dowelled	20	10	5	0
If ploughed and tongued headings, add	2	2	0	0
If ploughed and tongued edges, add	3	9	0	0
For tongues to edges of battens, add	6	3	0	0
If battens less than 5 inch, add	1	8	0	0

FRAMED GROUNDS,

	Labour and Nails. s.	d.
At per foot super.		
Common framed grounds	0	4
1 inch do., ploughed for plastering	0	4
1¼ inch do. do. do.	0	5
1½ inch do. do. do.	0	5

SKIRTINGS,

At per foot super.		
Plain skirtings	0	2
Do. do. raking cut to steps	0	4
Torus skirtings	0	4
Do. do. raking cut to steps	0	5

GUTTERS AND BEARERS,

At per foot super.		
Inch or whole deal	0	4½

DOOR LININGS,

At per foot super.		
Plain, single rebated	0	3½
Plain, single rebated, and beaded	0	3¾
Plain, double rebated	0	4
Plain, double rebated, and double beaded	0	5
Square framed jambs, each in 2 panels, and soffit in 1 panel	0	6
If bead, butt, or moulded, add	0	¾
Bead, flush, or quirk moulded, add	0	1½
Raised panel and moulded, add	0	2½
For every extra panel, if square	0	1¼
Do. flush or moulded	0	1½
If double rebated	0	1¼
If double beaded	0	¾

LEDGED DOORS,

At per foot super.		
1¼ rough edges shot	0	4
Add, if ploughed and tongued	0	¾
if ploughed and beaded	0	1¼
if wrought each side	0	¾
if braced	0	1½
if hung folding	0	1½
if 1 inch thicker	0	3

FRAMED PARTITIONS

	Labour & Nails. s.	d.
At per foot super.		
1½ inch square framed	0	4
2 inch do. do.	0	4½
Add, if bead, butt, or moulded	0	1½
„ if bead, flush, or quirk moulded	0	2½

DEAL MOULDINGS,

Fixed complete, at per foot super.

Common mouldings	0	8
Add, if quirked	0	¾

Small mouldings can be measured at per foot run.

DOORS HUNG COMPLETE,

At per foot super.

Two panel square framed	0	4
Add for every additional 2 panels—		
If framed square,		
For 1½ inch deal	0	1
2 inch do.	0	1¼
2½ inch do.	0	1½
If framed bead, butt, and square,		
For 1½ inch deal	0	1¼
2½ inch do.	0	1½
If framed bead, flush, and square,		
For 1½ inch deal	0	1½
2 inch do.	0	2
2½ inch do.	0	2½
If framed quirk O. G. and bead, and square, or quirk Ov., and bead and square,		
For 1½ inch deal	0	1¼
2½ inch do.	0	1½
If double marquis, 4½ inch wide	0	1¼
„ „ 5½ or 6 inch wide	0	2½
Hung folding	0	¾

WINDOW LININGS,

At per foot super.

Inch deal, two panel square, framed back linings	0	6
„ if bead, butt, or moulded, add	0	¾
„ if bead, flush, or quirk moulding, add	0	1¼
For each panel above two, if square	0	1½
„ „ if moulded	0	1½
„ „ if splayed	0	½

WINDOW BACKS, ELBOWS, AND SOFFITS,

At per foot super.

	Labour & Nails. s.	d.
Inch deal, plain keyed, or two panel square backs	0	5
Do. two panel square backs, elbows, and soffits	0	6
Add, for each panel above three,		
,, if splayed	0	½
,, if bead, butt, or moulded	0	¾
,, if bead, flush, or quirk moulded	0	1¼

BOXINGS TO WINDOWS,

At per foot super.

Framed, rebated, and beaded boxings	0	6
Splayed, flush, rebated, and beaded boxings	0	7

INSIDE WINDOW SHUTTERS,

At per foot super.

¾ inch deal clamped flaps in one height	0	7
Inch deal two panel square in one height	0	7½
For every panel above two,		
If framed square	0	1¼
If bead, butt, or moulded	0	1¼
If bead, flush, or quirk moulded	0	1½
Quirk O. G. and bead, or quirk ov., and bead and square	0	1½
For every extra height, add	0	¾

SASHES AND FRAMES HUNG COMPLETE,

At per foot super.

Sashes—		
1½ inch deal ovolo sashes	0	3
Do. wainscot or mahogany	0	4
If 2 or 2½ inch sashes deal, add	0	1½
If do. wainscot or mahogany, add	0	1½
If astragal and hollow in deal, add	0	¾
If do. in wainscot and mahogany, add	0	1¼
Frames—		
Deal cased frames, oak sunk sills, double pulley, P. B. and P. S., single hung	0	4
If prepared for 2 or 2½ sashes, add	0	¾
If prepared with wainscot or mahogany P. P.B^{ds}. and P. slips	0	5
If for 2 or 2½ inch sashes, add	0	1
If double hung, add	0	¾

STAIRCASES,

At per foot super.	Labour & Nails. s.	d.
Common steps and risers, and two fir carriages	0	4
Do. moulded nosings and close strings	0	6
Do. do. mitred to cut string boards, and dovetailed to balustres	0	7
Add,		
If winders, circular one end	0	2½
Do. do. circular two ends	0	5
Do. do. geometrical, with wrought and blocked carriages	0	3½
Riser-tongued to step bottom edge	0	1¼
Do. do. both edges	0	2½
Feather-tongued joints	0	1¼
Add,		
Quarter curtail, glued upright, each	3	4
Do. blocked and veneered, each	5	10
Proper curtail, step and riser, each	11	0
Return moulded nosing, each	1	3
Return circular, each	2	1
Plain cut bracket, each	1	3
Circular cut bracket, each	2	1
Housing to step and riser, each	0	6
„ to winders, each	0	7½
„ to moulded nosings, each	0	10
„ to circular ends, each	2	3½

OUTSIDE STRINGS TO STAIRS,

At per foot super.

Whole deal plain	0	5
Whole deal sunk	0	6
Whole deal sunk and moulded	0	6¾
Whole deal sunk, moulded, and cut	0	8
Whole deal sunk, moulded, cut, and mitred to risers	0	8½

If wreathed, four times the above.
If ramped, once and a half.

WALL STRINGS,

At per foot super.

Plain and plugging	0	5
If moulded, add	0	1
If rebated for plastering, add	0	1¾

DADOS,

At per foot super.

	Labour & Nails. s.	d.
Proper dado, with dovetailed keys, joints secured with slips, and dovetails hung to grounds by grooves keyed into do., and dado	0	4
Add,		
If raking, scribed to steps	0	1¼
If raking, scribed to moulded nosings	0	1¼
If base, grooved into floor	0	½
For each external mitre beyond two in a room	1	1¾
If circular on the plan, double the above.		
If wreathed, treble the above.		

COLUMNS AND PILASTERS,

At per foot super.

1¼ inch deal plain pilasters, properly glued and blocked	0	6¾
Do. do. diminished	0	9
1¼ inch deal diminished columns, properly glued and blocked, under 14 inches diameter	2	1
Do. do. above 14 inches diameter	1	9
Add, for—		
Arris or deep fluting to pilasters, one inch wide	0	1¼
„ „ „ two inches wide	0	1½
„ „ „ three inches wide	0	2¾
Arris or deep fluting to columns, one inch wide	0	1½
„ „ „ two inches wide	0	2¾
„ „ „ three inches wide	0	3¼
Straight grooves to columns	0	1¼
Headings to flutes to columns	0	4
Straight grooves to pilasters	0	¾
Headings to flutes to pilasters	0	2¾

In the foregoing list of Carpenters' and Joiners' Prices, all calculations in respect of materials have been omitted, owing to the very unsettled state of the market at the present time, (March, 1853,) and the fluctuations to which it is subject. The charges for labour being less affected by fluctuations of a similar nature, can be more satisfactorily relied on as permanent approximations to reasonable remuneration to the tradesman, and may consequently be taken as a basis for estimates for some years to come.

The timber must be added at its measured value, according to market price at the time being. The method of ascertaining the value of a cube foot of timber from the prime cost prices is given in the Chapter on Artificers' Work, and the following Tables will be found useful.

Table showing the price to be charged per foot cube for Fir, or other Timber, used in measured work, calculated at the various rates of prime cost, standing at the head of the several columns, allowing 5s. for cartage, 10s. for sawing, 10s. for waste, and £1 5s. for profit, per load.

	PRIME COST PER LOAD.																										
	£.	s.	d.	£.	s.	d.	£.	s.	d.	£.	s.	d.	£.	s.	d.	£.	s.	d.	£	s.	d.	£.	s.	d.			
	2	10	0	2	18	4	3	6	8	3	15	0	4	3	4	4	11	8	5	0	0	5	8	4	5	16	8
Fir Timber, no labour	0	2	0	0	2	2	0	2	4	0	2	6	0	2	8	0	2	10	0	3	0	0	3	2	0	3	4
Fir Timber, in bond, Plates, Curb, &c., labour included.	0	2	4	0	2	6	0	2	8	0	2	10	0	3	0	0	3	2	0	3	4	0	3	6	0	3	8
Fir Timber, framed	0	2	8	0	2	10	0	3	0	0	3	2	0	3	4	0	3	6	0	3	8	0	3	10	0	4	0
Fir Timber, truss framed.	0	2	10	0	3	0	0	3	2	0	3	4	0	3	6	0	3	8	0	3	10	0	4	0	0	4	2
Fir Timber, framed and chamfered	0	2	10	0	3	0	0	3	2	0	3	4	0	3	6	0	3	8	0	3	10	0	4	0	0	4	2
Fir Timber, wrought and framed	0	3	1	0	3	3	0	3	5	0	3	7	0	3	9	0	3	11	0	4	1	0	4	3	0	4	5
Fir Timber, wrought, framed, and rebated	0	3	3	0	3	5	0	3	7	0	3	9	0	3	11	0	4	1	0	4	3	0	4	5	0	4	7
Fir Timber, wrought, framed, rebated, and beaded	0	3	6	0	3	8	0	3	10	0	4	0	0	4	2	0	4	4	0	4	6	0	4	8	0	4	10
Fir Timber, wrought, framed, rebated and double beaded	0	3	8	0	3	10	0	4	0	0	4	2	0	4	4	0	4	6	0	4	8	0	4	10	0	5	0
Fir Timber, in proper door cases	0	3	11	0	4	1	0	4	3	0	4	5	0	4	7	0	4	9	0	4	11	0	5	1	0	5	3

Table showing the price to be charged per foot cube for Fir, or other Timber, used in measured work, calculated at the various rates of prime cost, standing at the head of the several columns, allowing 5s. for cartage, 10s. for sawing, 10s. for waste, and £1 5s. for profit per load.

	PRIME COST PER LOAD.																										
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.			
	6	5	0	6	13	4	7	1	8	7	10	0	7	18	4	8	6	8	8	15	0	9	3	4	10	0	0
Fir Timber, no labour	0	3	6	0	3	8	0	3	10	0	4	0	0	4	2	0	4	4	0	4	6	0	4	8	0	5	0
Fir Timber, in bond, Plates, Curb, &c., labour included	0	3	10	0	4	0	0	4	2	0	4	4	0	4	6	0	4	8	0	4	10	0	5	0	0	5	4
Fir Timber, framed	0	4	2	0	4	4	0	4	6	0	4	8	0	4	10	0	5	0	0	5	2	0	5	4	0	5	8
Fir Timber, truss framed	0	4	4	0	4	6	0	4	8	0	4	10	0	5	0	0	5	2	0	5	4	0	5	6	0	5	10
Fir Timber, framed and chamfered	0	4	4	0	4	6	0	4	8	0	4	10	0	5	0	0	5	2	0	5	4	0	5	6	0	5	10
Fir Timber, wrought and framed	0	4	7	0	4	9	0	4	11	0	5	1	0	5	3	0	5	5	0	5	7	0	5	9	0	6	1
Fir Timber, wrought, framed, and rebated	0	4	9	0	4	11	0	5	1	0	5	3	0	5	5	0	5	7	0	5	9	0	5	11	0	6	3
Fir Timber, wrought, framed, rebated, and beaded	0	5	0	0	5	2	0	5	4	0	5	6	0	5	8	0	5	10	0	6	0	0	6	2	0	6	6
Fir Timber, wrought, framed, rebated, and double beaded	0	5	2	0	5	4	0	5	6	0	5	8	0	5	10	0	6	0	0	6	2	0	6	4	0	6	8
Fir Timber, in proper door cases	0	5	5	0	5	7	0	5	9	0	5	11	0	6	1	0	6	3	0	6	5	0	6	7	0	6	11

Table showing the Length of Timber of any Scantling contained in a foot cube.

Scantling.		Length.		Scantling.		Length.		Scantling.		Length.	
in.	in.	ft.	in.	in.	in.	ft.	in.	in.	in.	ft.	in.
2	**2**	**36**	**0**	**4**	**4**	**9**	**0**	**6**	**10½**	**2**	**3**
	2½	28	9		4½	8	0		11	2	2
	3	24	0		5	7	2		11½	2	1
	3½	20	7		5½	6	6		12	2	0
	4	18	0		6	6	0	**7**	**7**	**2**	**11**
	4½	16	0		6½	5	6		7½	2	9
	5	14	5		7	5	1		8	2	6
	5½	13	1		7½	4	9		8½	2	5
	6	12	0		8	4	6		9	2	3
	6½	11	1		8½	4	3		9½	2	2
	7	10	3		9	4	0		10	2	1
	7½	9	7		9½	3	9		10½	1	11
	8	9	0		10	3	7		11	1	10
	8½	8	6		10½	3	5		11½	1	9
	9	8	0		11	3	3		12	1	8
	9½	7	7		11½	3	2	**8**	**8**	**2**	**3**
	10	7	3		12	3	0		8½	2	1
	10½	6	10	**5**	**5**	**5**	**9**		9	2	0
	11	6	6		5½	5	3		9½	1	10
	11½	6	4		6	4	10		10	1	9
	12	6	0		6½	4	5		10½	1	8
3	**3**	**16**	**0**		7	4	1		11	1	7
	3½	13	8		7½	3	10		11½	1	7
	4	12	0		8	3	7		12	1	6
	4½	10	8		8½	3	5	**9**	**9**	**1**	**9**
	5	9	7		9	3	2		9½	1	8
	5½	9	0		9½	3	0		10	1	7
	6	8	0		10	2	10		10½	1	6
	6½	7	4		10½	2	9		11	1	5
	7	6	10		11	2	8		11½	1	4
	7½	6	4		11½	2	6		12	1	4
	8	6	0		12	2	4	**10**	**10**	**1**	**5**
	8½	5	8	**6**	**6**	**4**	**0**		10½	1	4
	9	5	4		6½	3	8		11	1	4
	9½	5	0		7	3	5		11½	1	3
	10	4	10		7½	3	2		12	1	2
	10½	4	6		8	3	0	**11**	**11**	**1**	**2**
	11	4	4		8½	2	10		11½	1	2
	11½	4	2		9	2	8		12	1	1
	12	4	0		9½	2	6	**12**	**12**	**1**	**0**
					10	2	5				

Table showing the Price to be charged per foot run for Scantling of Fir, or other Timber, calculated at various Prices per foot cube.

Scantling.	2*s.* 6*d.* per ft. cube.	3*s.* 0*d.* per ft. cube.	3*s.* 6*d* per ft. cube.	Scantling.	2*s.* 6*d.* per ft. cube.	3*s.* 0*d.* per ft. cube.	3*s.* 6*d.* per ft. cube.
2—2	0 1	0 1	0 1¼	**5—7**	0 7½	0 8¾	0 10½
2½	0 1¼	0 1¼	0 1½	7½	0 8	0 9½	0 11¼
3	0 1¼	0 1½	0 1¾	8	0 8½	0 10	1 0
3½	0 1½	0 1¾	0 2¼	8½	0 9	0 10¾	1 0¾
4	0 1¾	0 2	0 2½	9	0 9½	0 11¼	1 1½
4½	0 2	0 2¼	0 2¾	9½	0 10¼	1 0	1 2¼
5	0 2¼	0 2½	0 3	10	0 10½	1 0½	1 3½
5½	0 2½	0 2¾	0 3¼	10½	0 11¼	1 1¼	1 3¾
6	0 2½	0 3	0 3½	11	0 11½	1 1¾	1 4
6½	0 2¾	0 3¼	0 4	11½	1 0	1 2¼	1 4¾
7	0 3	0 3½	0 4¼	12	1 0½	1 3	1 5½
7½	0 3¼	0 3¾	0 4½	**6—6**	**0 7½**	**0 9**	**0 10½**
8	0 3½	0 4	0 4¾	6½	0 8¼	0 9¾	0 11½
8½	0 3¾	0 4¼	0 5	7	0 8¾	0 10½	1 0¼
9	0 3¾	0 4½	0 5¼	7½	0 9½	0 11¼	1 1¼
9½	0 4	0 4¾	0 5¾	8	0 9¾	1 0	1 2
10	0 4¼	0 5	0 6	8½	0 10	1 0¾	1 3
10½	0 4½	0 5¼	0 6¼	9	0 11¼	1 1½	1 3¾
11	0 4¾	0 5½	0 6½	9½	1 0	1 2¼	1 4¾
11½	0 5	0 5¾	0 6¾	10	1 0½	1 3	1 5½
12	0 5	0 6	0 7	10½	1 1¼	1 3¾	1 6½
3—3	**0 2**	**0 2¼**	**0 2¾**	11	1 1¾	1 4½	1 7¼
3½	0 2¼	0 2¾	0 3¼	11½	1 2½	1 5¼	1 8¼
4	0 2½	0 3	0 3½	12	1 3	1 6	1 9
4½	0 3	0 3¼	0 4	**7—7**	**0 10¼**	**1 0¼**	**1 2½**
5	0 3¼	0 3¾	0 4½	7½	0 11	1 1¾	1 3½
5½	0 3½	0 4¼	0 5	8	0 11¾	1 2	1 4½
6	0 3¾	0 4½	0 5¼	8½	1 0½	1 3	1 5½
6½	0 4¼	0 5	0 5¾	9	1 1¼	1 3¾	1 6½
7	0 4½	0 5¼	0 6¼	9½	1 2	1 4¾	1 7½
7½	0 4¾	0 5¾	0 6¾	10	1 2¾	1 5½	1 8½
8	0 5	0 6	0 7	10½	1 3½	1 6½	1 9½
8½	0 5½	0 6½	0 7½	11	1 4	1 7¼	1 10½
9	0 5¾	0 6¾	0 8	11½	1 4¾	1 8¼	1 11½
9½	0 6	0 7¼	0 8½	12	1 5½	1 9¼	2 0½
10	0 6¼	0 7½	0 8¾	**8—8**	**1 1½**	**1 4**	**1 7**
10½	0 6¾	0 8	0 9¼	8½	1 2¼	1 5	1 8
11	0 7	0 8¼	0 9¾	9	1 3	1 6	1 9
11½	0 7¼	0 8¾	0 10¼	9½	1 4	1 7	1 10¼
12	0 7½	0 9	0 10½	10	1 5	1 8	1 11½
4—4	**0 3½**	**0 4**	**0 4¾**	10½	1 6	1 9	2 0¾
4½	0 4	0 4½	0 5½	11	1 7	1 10	2 1¾
5	0 4¼	0 5	0 6	11½	1 7½	1 11	2 3
5½	0 4¾	0 5½	0 6½	12	1 8	2 0	2 4
6	0 5	0 6	0 7	**9—9**	**1 5**	**1 8¼**	**1 11½**
6½	0 5½	0 6½	0 7¾	9½	1 6	1 9¼	2 1
7	0 6	0 7	0 8¼	10	1 7	1 10½	2 2½
7½	0 6½	0 7½	0 9	10½	1 8	1 11¾	2 3¾
8	0 6¾	0 8	0 9½	11	1 8¾	2 0¾	2 5
8½	0 7¼	0 8½	0 10	11½	1 9¾	2 2	2 6½
9	0 7½	0 9	0 10½	12	1 10½	2 3	2 7½
9½	0 8	0 9½	0 11¼	**10—10**	**1 10**	**2 1**	**2 7**
10	0 8½	0 10	0 11¾	10½	1 10½	2 2¼	2 7½
10½	0 9	0 10½	1 0½	11	1 11	2 3½	2 8
11	0 9¼	0 11	1 1	11½	2 0	2 5¼	2 9½
11½	0 9¾	0 11½	1 1½	12	2 1	2 6	2 11
12	0 10	1 0	1 2	**11—11**	**2 1¼**	**2 6¼**	**2 11¼**
5—5	**0 5½**	**0 6½**	**0 7¾**	11½	2 2½	2 7¾	3 2
5½	0 6	0 7	0 8¼	12	2 3½	2 9	3 2¼
6	0 6¼	0 7½	0 8¾	**12—12**			
6½	0 7	0 8¼	0 9¾				

Table showing the Price to be charged per foot run for Scantling of Fir, or other Timber, calculated at various Prices per foot cube.

Scantling.	4*s.* 0*d.* per ft. cube.	4*s.* 6*d.* per ft. cube.	5*s.* 0*d.* per ft. cube.	Scantling.	4*s.* 0*d.* per ft. cube.	4*s.* 6*d.* per ft. cube.	5*s.* 0*d.* per ft. cube
2—2	**0 1½**	**0 1½**	**0 1¾**	**5—7**	**1 0**	**1 1½**	**1 3**
2½	0 1¾	0 2	0 2¼	7½	1 0¾	1 3	1 4
3	0 2	0 2¼	0 2½	8	1 1½	1 4½	1 5
3½	0 2½	0 2¾	0 3	8½	1 2¼	1 4¾	1 6
4	0 2¾	0 3	0 3½	9	1 3	1 5	1 6¾
4½	0 3	0 3½	0 3¾	9½	1 4¼	1 6½	1 7¾
5	0 3½	0 4	0 4¼	10	1 5½	1 7¾	1 9
5½	0 3¾	0 4¼	0 4¾	10½	1 6	1 8¼	1 9¾
6	0 4	0 4½	0 5	11	1 6¼	1 8¾	1 10¾
6½	0 4½	0 5	0 5½	11½	1 7	1 9½	2 11¾
7	0 4¾	0 5¼	0 6	12	1 8	1 10½	2 1
7½	0 5	0 5¾	0 6¼	**6—6**	**1 0**	**1 1½**	**1 3**
8	0 5½	0 6	0 6¾	6½	1 1	1 2¾	1 4¼
8½	0 5¾	0 6½	0 7¼	7	1 2	1 3¾	1 5½
9	0 6	0 6¾	0 7½	7½	1 3	1 5	1 6¾
9½	0 6½	0 7¼	0 8	8	1 4	1 6	1 8
10	0 6¾	0 7½	0 8½	8½	1 5	1 7¼	1 9¼
10½	0 7	0 7¾	0 9	9	1 6	1 8¼	1 10½
11	0 7¼	0 8¼	0 9¼	9½	1 7	1 9½	1 11¾
11½	0 7¾	0 8¾	0 9¾	10	1 8	1 10½	2 1
12	0 8	0 9	0 10	10½	1 9	1 11¾	2 2¼
3—3	**0 3**	**0 3½**	**0 3¾**	11	1 10	2 0¾	2 3½
3½	0 3½	0 4	0 4½	11½	1 11	2 2	2 4¾
4	0 4	0 4½	0 5	12	2 0	2 3	2 6
4½	0 4½	0 5¼	0 5¾	**7—7**	**1 4½**	**1 6½**	**1 8½**
5	0 5	0 5¾	0 6¼	7½	1 5¾	1 8	1 10
5½	0 5½	0 6¼	0 7	8	1 7	1 9¼	1 11½
6	0 6	0 6¾	0 7½	8½	1 8¼	1 10½	2 2
6½	0 6½	0 7½	0 8¼	9	1 9¼	1 11¾	2 2¼
7	0 7	0 8	0 8¾	9½	1 10½	2 1¼	2 3¾
7½	0 7½	0 8½	0 9½	10	1 11½	2 2½	2 5¼
8	0 8	0 9	0 10	10½	2 0¾	2 3¾	2 6½
8½	0 8½	0 9¾	0 10¾	11	2 1¾	2 5	2 8
9	0 9	0 10¼	0 11¼	11½	2 3	2 6½	2 9½
9½	0 9½	0 10¾	1 0	12	2 4	2 7¼	2 11
10	0 10	0 11¼	1 0½	**8—8**	**1 9½**	**2 0**	**2 3**
10½	0 10½	1 0	1 1¼	8½	1 10¾	2 1½	2 4½
11	0 11	1 0½	1 1¾	9	2 0	2 3	2 6
11½	0 11½	1 1	1 2½	9½	2 1½	2 4½	2 7½
12	1 0	1 1½	1 3	10	2 2¾	2 6	2 9
4—4	**0 5½**	**0 6**	**0 6¾**	10½	2 4	2 7½	2 11
4½	0 6¼	0 6¾	0 7¾	11	2 5¼	2 9	3 0¾
5	0 6¾	0 7½	0 8½	11½	2 6¾	2 10½	3 2½
5½	0 7½	0 8¼	0 9¼	12	2 8	3 0	3 4
6	0 8	0 9	0 10	**9—9**	**2 2¾**	**2 6**	**2 9**
6½	0 8¾	0 9¾	0 11	9½	2 4½	2 8	2 11¼
7	0 9½	0 10½	0 11¾	10	2 6	2 10	3 1½
7½	0 10¼	0 11¼	1 0¾	10½	2 7½	2 11¾	3 3½
8	0 10¾	1 0	1 1½	11	2 9	3 1¼	3 5¼
8½	0 11½	1 0½	1 2¼	11½	2 10½	3 3	3 7¼
9	1 0	1 1½	1 3	12	3 0	3 4½	3 9
9½	1 0¾	1 2¼	1 4	**10—10**	**2 11**	**3 3½**	**3 8**
10	1 1½	1 3	1 4¾	10½	3 0	3 4½	3 9
10½	1 2¼	1 3½	1 5½	11	3 0¾	3 5	3 9¾
11	1 2¾	1 4	1 6¼	11½	3 2½	3 7	4 0
11½	1 3½	1 5	1 7¼	12	3 4	3 9	4 2
12	1 4	1 6	1 8	**11—11**	**3 4½**	**3 9½**	**4 2½**
5—5	**0 8¾**	**0 10**	**0 11**	11½	3 6¼	3 11½	4 4¾
5½	0 9½	0 10¾	0 11¾	12	3 8	4 1½	4 7
6	0 10	0 11¼	1 0½	**12 12**			
6½	0 11	1 0½	1 1¾				

SECT. II.—*Mason's Prices.*

		s.	d.
Labour, squaring and laying New York or Purbeck paving	per foot super.	0	1¼
If in courses, add		0	½

LABOUR ON PORTLAND OR SIMILAR STONE.

N.B. Sawing to be taken as half plain work.

Plain work to bond stones	per foot super.	0	8½
„ „ to beds and joints	„	0	11
„ „ rubbed face	„	1	0½
„ „ „ circular	„	1	5½
Sunk work „	„	1	3
„ „ „ „	„	1	7
Moulded work rubbed	„	1	5½
„ „ „ circular	„	2	1
Circular work to shafts of columns having the neck moulding, or part of the base worked in the same stone	„	1	8
Circular circular or spherical work to domes or balls	„	2	6
If rubbed, add	„	0	3
Taking up, squaring, and relaying old paving	„	0	2½
Add, if in courses	„	0	1

LABOUR ON STATUARY OR VEIN MARBLE, INCLUDING SAWING, WORKING, AND POLISHING.

Plain work	per foot super.	4	4½
Circular work	„	6	3
Sunk work	„	8	4
Moulded work	„	11	11
Circular sunk work	„	11	11
Circular moulded work	„	15	0

ON OLD WORK.

Old vein marble chimney, reset	„	0	7½
„ „ squared and reset	„	0	10
„ „ sanded, grounded & squared	„	1	0½
„ „ sanded, grounded, squared and reset	„	1	3
„ „ cleaned and reset, sanded	„	1	3
„ „ polished and reset		1	10½
„ „ sawed, sanded, polished, squared, & reset	„	3	1½

The above prices are confined to labour only. The prime cost of stone and marble varying considerably in different localities, according to the expense of carriage and other circumstances, it would answer no useful purpose in a book intended for general circulation, to include any calculation for materials; especially as price lists of the various kinds can at all times be obtained of the merchants and dealers.

As an illustration of this difference, the annexed extract from the price list of Messrs. Randell and Saunders, for Bath stone, is annexed. It will be seen that the same description of goods varies more than cent. per cent. at different stations.

PRICES.			At Bristol.		Paddington.		Liverpool.		
		s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
BLOCK.									
Corsham Down, delivered into trucks, at Corsham	per foot cube	0	7	0	9	1	4	1	6
Combe Down, ditto at Bath	,,	0	8	0	9½	1	5		
Box ground stone, ditto at Box or Corsham	,,	0	7	0	9½	1	4		
Farley Down, ditto at Box	,,	0	8	0	9½	1	5		
Corn Grit, ditto at Corsham	,,	0	5	0	7	1	2		
Selected Blocks, 1*d.* per foot extra.									
Blocks, of large dimensions, or cut to order, supplied at a moderate cost.									
LANDING.									
Four inch, under 24 feet	per foot super.	0	3½	0	4½	0	6½	0	7½
Ditto, above 24 feet	,,	0	4½	0	5½	0	7½	0	8½
Six inch, under 24 feet	,,	0	4½	0	4½	0	9½	0	10½
Ditto above 24 feet	,,	0	5½	0	6½	0	10½	0	11½
PAVING.									
Three inch, corn grit	,,	0	2			0	5		
Ditto ditto, Corsham Down	,,	0	3			0	6		
ASHLAR.									
Corsham Down ashlar, 4 inch	,,	0	2½	0	2¾	0	5½	0	6
Ditto, 5 inch	,,	0	2¾	0	3¼	0	6½		
Ditto, 6 inch	,,	0	3	0	3¾	0	7½	0	9
Ditto, 7 inch	,,	0	3½	0	4½	0	8¾		
Ditto, 8 inch	,,	0	4½	0	5½	0	10½	1	0
This Stone is cut to range in courses, 10, 12, or 14 inches deep; a small allowance being made in each case for dressing.									
RANGE STONE.									
Sawn range stone	per yard	1	3	1	9	3	6		
This Stone is cut to range in courses, 4, 5, 6, 7, and 8 inches deep, and varies from 3 to 7 inches wide; 5 yards make a ton.									
QUOINS. Random sizes	per foot super.	0	3						
WALL STONES.	per ton	1	0						

SECT. III—*Bricklayer's Prices.*

		Labour. s.	d.
Concrete—Labour in mixing, wheeling, throwing in from a stage, and puddling, (where required to be done), including erection of scaffolding	per yard cube	0	10
Brickwork.	per rod	37	1
Extra labour to maim facings		0	1

PAVING.

Brick paving laid flat in sand	per yard	0	4
„ laid on edge in sand	„	0	7
„ laid flat in mortar	„	0	5
„ laid on edge in mortar	„	0	8
Paving brick paving laid flat in sand	„	0	4
„ laid on edge in ditto	„	0	9½
„ laid flat in mortar	„	0	7
„ laid on edge in mortar	„	0	11
Clinker paving on edge in sand	„	1	0
10 to 12 inch tile paving	„	0	1

TILING.

Pan tiling laid dry	per square	3	2
Pan tiling pointed outside	„	5	2
„ inside and out	„	5	11
Plain tiling laid to a 4 inch guage	„	5	7
„ laid to a 3½ inch ditto	„	5	9
„ laid to a 3 inch ditto	„	5	11

The prices of bricks, slates, and tiles, vary in price in different localities, at the present time, (March, 1853), they are very dear, so that any calculation on account of materials would not be useful in this place.

SECT. IV—*Plasterer's Prices.*

Rough render		0	2
Floating ditto		0	2¼
Setting		0	1¾
Lathing		0	2
If circular work, add on the lathing, and also on each coat of plastering		0	1
If to groins, add as above		0	1

SECT. V—*Ironmonger's Prices.*

AIR BRICKS.

	Per Doz. s.	d.		Per Doz. s.	d.
Hollow sides	6	0	Half bricks	4	0
Hollow sides, heavy	7	0	Half bricks, heavy	4	6
Full sides	9	0	Half bricks	5	0
Full sides, heavy	12	0	Full sides, heavy	5	6

BRASS BOLTS.

½ inch flush brass bolts.

	per doz. s.	d.
2 inches	1	10
2½ „	2	3
3 „	2	9
4 „	3	8
5 „	4	6
6 „	5	6
7 „	6	4
8 „	7	3
9 „	8	2
10 „	9	0
11 „	10	0
12 „	10	10

½ inch sunk slide.

	per doz. s.	d.
4 inches	5	0
5 „	6	3
6 „	7	6
7 „	8	9
8 „	10	0
9 „	11	3
10 „	12	6
11 „	13	9
12 „	15	0

⅝ inch sunk slide.

	per doz. s.	d.
4 inches	5	4
5 „	6	8
6 „	8	0
7 „	9	4
8 „	10	8
9 „	12	0
10 „	13	4
11 „	14	8
12 „	16	0

¾ inch sunk slide.

	per doz. s.	d.
4 inches	6	0
5 „	7	6
6 „	9	0
7 „	10	6
8 „	12	0
9 „	13	6
10 „	15	0
11 „	16	6
12 „	18	0

⅞ inch sunk slide.

	per doz. s.	d.
4 inches	7	0
5 „	8	9
6 „	10	6
7 „	12	3
8 „	14	0
9 „	15	9
10 „	17	6
11 „	19	3
12 „	21	0

1 inch sunk slide.

	per doz. s.	d.
4 inches	8	0
5 „	10	0
6 „	12	0
7 „	14	0
8 „	16	0
9 „	18	0
10 „	20	0
11 „	22	0
12 „	24	0

NIGHT BOLTS.

6 inch	3s. each.	7 inch	4s. each.

BRASS SOCKET BOLTS,

All brass.	per doz. s.	d.	With iron bolts and back plates.	per doz. s.	d.
3 inches	18	0	3 inches	16	0
4 „	24	0	4 „	20	0
5 „	30	0	5 „	24	0
6 „	36	0	6 „	28	0
7 „	42	0	7 „	33	0
8 „	50	0	8 „	40	0
9 „	60	0	9 „	48	0

STRONG BRASS SOCKET BOLTS,

All brass.	per doz. s.	d.	With iron bolts and back plates.	per doz. s.	d.
3 inches	16	0	3 inches	12	6
4 „	19	0	4 „	15	6
5 „	23	0	5 „	19	0
6 „	28	0	6 „	23	0
7 „	34	0	7 „	28	0
8 „	42	0	8 „	33	0
9 „	50	0	9 „	38	0

SOLID BRASS SHIP BOLTS.

	per doz. s.	d.		per doz. s.	d.
3 inches	26	6	6 inches	45	6
4 „	32	0	7 „	55	0
5 „	40	0			

SHIP BOLTS, ALL BRASS, SMOOTH SANDED.

	per doz. s.	d.		per doz. s.	d.
3 inches	12	0	6 inches	22	0
4 „	13	6	8 „	40	0
5 „	18	0			

RACK AND SPRING BRASS BOLTS.

1 inch wide, 12 inches long, 4*s.* 3*d.* each.

RACK AND SPRING IMPROVED ESPAGNIOLETTE BRASS BOLTS.

$\frac{5}{8}$ 3*s.* $\frac{3}{4}$ 3*s.* 6*d.* $\frac{7}{8}$ 4*s.*

BRASS BOLTS FOR BLINDS.

From 2*s.* to 3*s.* per dozen.

IRON NIGHT BOLTS.

	per doz. s.	d.		per doz. s.	d.
6 inches	15	0	8 inches	20	0
7 „	17	0			

DOOR CHAIN BOLTS.

	per doz. s.	d.		per doz. s.	d.
5 inches	8	6	9 inches	15	0
6 „	9	6	10 „	18	0
7 „	10	6	11 „	22	0
8 „	12	0	12 „	26	0

COTTAGE OR PORTABLE IRON OVENS.

Inside Measure.

9 inches long, 7 inches wide, $6\frac{1}{4}$ deep, 11*s.* 3*d.* each.
11 „ $8\frac{1}{2}$ „ $6\frac{1}{2}$ „ 14*s.* „

CASEMENT AND FRENCH WINDOW BRASS FASTENERS.

From 5*s.* 6*d.* to 50*s.* per dozen.

HINGES, BRASS BUTTS.

	per doz. s.	d.			per doz. s.	d.
$\frac{3}{4}$ inch, from	0 10	to 1 0	2 inch, from	2 9	to 5	9
$\frac{7}{8}$ „	0 11	1 1	$2\frac{1}{4}$ „	3 6	7	6
1 „	1 1	1 3	$2\frac{1}{2}$ „	4 6	9	0
$1\frac{1}{8}$ „	1 3	1 6	$2\frac{3}{4}$ „	5 6	12	0
$1\frac{1}{4}$ „	1 4	1 9	3 „	7 3	16	0
$1\frac{3}{8}$ „	1 7	2 0	$3\frac{1}{4}$ „	9 0	20	0
$1\frac{1}{2}$ „	1 9	3 4	$3\frac{1}{2}$ „	11 0	28	0
$1\frac{5}{8}$ „	2 0	3 9	$3\frac{3}{4}$ „	14 0	34	0
$1\frac{3}{4}$ „	2 3	4 3	4 „	17 6	42	0
$1\frac{7}{8}$ „	2 6	4 9				

STRONG PROJECTING BRASS BUTTS, WITH POLISHED AND LACQUERED BACKS.

	per doz. s.	d.		per doz. s.	d.
$1\frac{3}{4}$ inches	5	9	3 inches	20	0
2 „	7	0	$3\frac{1}{4}$ „	31	0
$2\frac{1}{4}$ „	8	9	$3\frac{1}{2}$ „	34	0
$2\frac{3}{8}$ „	10	6	$3\frac{3}{4}$ „	39	0
$2\frac{1}{2}$ „	12	6	4 „	45	0
$2\frac{5}{8}$ „	15	0			

PROJECTING BRASS BUTTS, WITH POLISHED BACKS AND FRONTS.

	per pair. s. d.		per pair. s. d.
2 inches	1 0	3¼ inches	2 6
2¼ „	1 3	3½ „	3 0
2½ „	1 6	3¾ „	3 6
2¾ „	1 10	4 „	4 3
3 „	2 2		

SKEW BRASS BUTTS, WITH STEEL JOINTS.

From 7*s.* 9*d.* to 15*s.* per pair.

STRONG BROAD PROJECTING BRASS BUTTS, WITH POLISHED BACKS AND FRONTS.

	per doz. s. d.		per doz. s. d.
2 inch	1 4	2½ inch	2 2
2¼ „	1 7	2¾ „	2 9

WITH HOLLOW JOINTS.

	per doz. s. d.		per doz. s. d.
3 inch	3 0	3¾ inch	4 6
3¼ „	3 6	4 „	5 6
3½ „	4 0		

BRASS RISING HINGES ON STEEL SCREWS.

	per pair. s. d.		per pair. s. d.
3 inch	11 6	4 inch	15 0
3½ „	13 6	4½ „	17 6

BEST CAST IRON HINGES.

Pew Hinges, Japanned, per doz.		Egg Joint, Japanned, per doz.		Strong loose joint Parliament per doz.		Strong Knee'd Butts, per doz.		Loose Pew Butts, per doz.		Loose Butts Turned ends per doz.		Loose Butts per doz.		New Skew Butts, Turned ends per doz.		Back Flaps per doz.		Skew Butts per doz.		Pew Butts, Japanned, per doz.		Square Butts, per doz.		Edge Butts, per doz.		Sizes.
s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	inches.
3	0									2	8	1	8			1	5					1	6	0	10	1
		4	6							3	0	1	10			1	9					1	8	1	0	1¼
		4	6	4	9			1	8	3	3	2	0			2	4					2	0	1	3	1½
4	0			5	0			2	2	3	9	2	6			3	3			4	0	3	0	1	7	1¾
5	3	5	0	5	6			2	8	4	6	3	0			3	9			5	0	4	0	2	0	2
5	6	5	6	6	0			3	3	5	3	3	6			4	6	7	9	5	6	4	6	2	4	2¼
6	0	6	0	7	0	9	0	4	0	5	9	4	0	10	6	6	6	8	6	6	0			2	8	2½
6	9	6	6	8	0					6	6	4	9					9	3	6	9	8	0	3	2	2¾
		7	0	8	9	11	0	5	6	7	3	5	6	12	6			10	0					4	2	3
				9	6					8	1	6	4					11	3					4	9	3¼
						12	6	7	3	9	0	7	3	16	0			12	6					5	3	3½
				10	6													14	0					6	0	3¾
						18	0	8	9	10	6	8	9	20	0			15	6					6	6	4
				11	6	20	0																	8	0	4¼
				12	6	22	0	12	0	13	9	12	0	24	0			19	0					9	6	4½
								15	0	16	9	15	0	28	0			24	0					12	0	5
				13	6																			13	6	5¼
				14	6																			14	6	5½
														35	0			30	0					17	0	6
																								20	0	6½
																								23	0	7
																								30	0	7½
																								36	0	8
																								42	0	8½

BROAD CAST IRON BUTTS.

size.				per doz. s.	d.	size.				per doz. s.	d.
2	by	2	open	2	9	4	by	3	open	8	6
	,,	2¼	,,	3	3		,,	3¼	,,	8	9
	,,	2½	,,	3	6		,,	3½	,,	9	0
2¼	,,	2¼	,,	3	9		,,	3¾	,,	9	6
	,,	2½	,,	4	0		,,	4	,,	10	0
2½	,,	2¼	,,	3	9		,,	4¼	,,	10	6
	,,	2½	,,	4	3		,,	4½	,,	11	0
	,,	2¾	,,	4	6		,,	4¾	,,	11	9
	,,	3	,,	4	9		,,	5	,,	12	6
	,,	3¼	,,	5	3	4¼	,,	3¾	,,	10	6
2¾	,,	2½	,,	4	6		,,	4	,,	11	0
	,,	2¾	,,	5	0		,,	4¼	,,	11	6
	,,	3	,,	5	6		,,	4½	,,	12	6
3	,,	2½	,,	5	0		,,	5	,,	13	6
	,,	2¾	,,	5	6	4½	,,	3½	,,	12	0
	,,	3	,,	6	0		,,	3¾	,,	12	6
	,,	3¼	,,	6	6		,,	4	,,	13	0
	,,	3½	,,	7	0		,,	4¼	,,	13	6
	,,	3¾	,,	7	6		,,	4½	,,	14	0
	,,	4	,,	7	9		,,	4¾	,,	14	6
3¼	,,	2¾	,,	6	0		,,	5	,,	15	0
	,,	3	,,	6	6		,,	5¼	,,	15	9
	,,	3¼	,,	7	0		,,	5½	,,	16	6
	,,	3½	,,	7	6	5	,,	3½	,,	15	0
	,,	3¾	,,	8	0		,,	4	,,	16	0
	,,	4	,,	8	6		,,	4½	,,	17	0
3½	,,	3	,,	7	0		,,	5	,,	18	0
	,,	3¼	,,	7	6		,,	5½	,,	19	0
	,,	3½	,,	8	0		,,	6	,,	21	0
	,,	3¾	,,	8	6	5½	,,	4	,,	17	0
	,,	4	,,	8	9		,,	4½	,,	18	0
	,,	4¼	,,	9	3		,,	5	,,	19	6
	,,	4½	,,	9	6		,,	5½	,,	21	6
3¾	,,	3	,,	7	6		,,	6	,,	24	0
	,,	3¼	,,	8	0		,,	6½	,,	27	0
	,,	3½	,,	8	6	6	,,	4½	,,	20	0
	,,	3¾	,,	9	0		,,	5	,,	21	6
	,,	4	,,	9	6		,,	5½	,,	23	6
	,,	4¼	,,	10	3		,,	6	,,	26	0
	,,	4½	,,	11	0		,,	6½	,,	29	0

CROSS GARNET AND T HINGES.

No.		per pair. s.	d.	No.		per pair. s.	d.
1.	10 inch . .	0	5	4.	16 inch . .	0	9
2.	12 „ . .	0	6	5.	18 „ . .	1	0
3.	14 „ . .	0	8	6.	20 „ . .	1	3

Strong Cross Garnets, 5*d.* per lb.

HOOK AND EYE HINGES same price.

CAST IRON PARLIAMENT HINGES.

Joint.		Open.	per doz. s.	d.	Joint.		Open.	per doz. s.	d.
1¼	by	2½	4	9	2	by	3	7	0
1½	„	2	5	3	„	„	3½	7	3
„	„	3	5	6	„	„	4	7	6
1¾	„	2	6	3	2¼	„	4	8	6
„	„	2½	6	6	„	„	4½	9	6
„	„	3	6	9	2½	„	5	10	6
„	„	3½	7	0	„	„	6	12	0
2	„	1½	6	3	„	„	7	16	0
„	„	2	6	6	2¾	„	5½	12	6
„	„	2½	6	9	3	„	6	15	0

CAST IRON LATCHES, WITH WROUGHT FURNITURE.

		s.	d.		s.	d.	
Gate latch, with screws and nuts .					19	0	per dozen.
Common thumb latches .	from	2	3	to	4	6	„
New thumb latches .	„	4	6	„	11	0	„
Norfolk latches . .	„	4	8	„	14	6	„
Flush latches . . .					5	0	„
Strong fluted Norfolk latches .	from	5	6	„	12	0	„
Flush stable latches .	„	9	0	„	15	0	„
Jointed handle stable latches .					13	6	„
Secret latches, with moving plate					17	6	„
„ with drawback bolt					20	0	„
„ for gates .					10	0	„

Screws, Nails, &c.

BRASS HEADED NAILS.

	per doz. s.	d.		per doz. s.	d.
⅝ inch . . .	1	2	2 inch . .	2	9
¾ „ . .	1	3	2¼ „ . . .	3	3
⅞ „ . . .	1	4	2½ „ . .	3	9
1 „ . .	1	6	2¾ „ . . .	4	3
1¼ „ . . .	1	8	3 „ . .	5	0
1½ „ . .	1	9	3½ „ . . .	7	0
1¾ „ . . .	2	2	4 „ . .	8	6

BRASS PLATED HEAD COUNTER-SUNK NAILS.

	per doz. s.	d.		per doz. s.	d.
$\frac{5}{8}$ inch	1	0	$1\frac{3}{4}$ inch	2	0
$\frac{3}{4}$ „	1	1	2 „	2	3
$\frac{7}{8}$ „	1	3	$2\frac{1}{4}$ „	2	9
1 „	1	3	$2\frac{1}{2}$ „	3	0
$1\frac{1}{4}$ „	1	6	$2\frac{3}{4}$ „	3	6
$1\frac{1}{2}$ „	1	9	3 „	4	0

BRASS TAPER-HEADED NAILS.

	per doz. s.	d.		per doz. s.	d.
$\frac{5}{8}$ inch	1	7	2 inch	3	3
$\frac{3}{4}$ „	1	8	$2\frac{1}{4}$ „	3	9
$\frac{7}{8}$ „	1	9	$2\frac{1}{2}$ „	4	6
1 „	1	10	$2\frac{3}{4}$ „	5	3
$1\frac{1}{4}$ „	2	0	3 „	6	0
$1\frac{1}{2}$ „	2	3	$3\frac{1}{2}$ „	7	0
$1\frac{3}{4}$ „	2	9	4 „	8	6

BRASS SASH SCREWS.

From 2*s.* to 3*s.* 3*d.* per dozen.

WROUGHT NAILS.		s.	d.	CUT NAILS.		s.	d.
Threepenny	per 1000	1	6	Threepenny	per 1000	0	8
Fourpenny	„	1	9	Fourpenny	„	0	10
Sixpenny	„	2	2	Sixpenny	„	1	0
Tenpenny	„	3	0	Tenpenny	„	2	0
Twentypenny	„	4	0	Twentypenny	„	3	0
Twentyfourpenny	3*d.* per lb.			Larger sizes $2\frac{1}{2}$*d.* per lb.			
Spikes 3*d.* per lb.							

JOINER'S CUT BRADS.

		s.	d.			s.	d.
$\frac{1}{2}$ inch	per 1000	0	2	$1\frac{1}{4}$ inch	per 1000	0	5
$\frac{3}{4}$ „		0	3	$1\frac{1}{2}$ „		0	6
1 „		0	4	2 „		1	0

CUT FLOOR BRADS.

2, $2\frac{1}{2}$, and 3 inches, 2*d.* per lb.

Cut lath nails, 24*s.* per cwt. | Cast lath nails, 16*s.* per cwt.

SASH LINE, at per gross of yards.

	s.	d.		s.	d.
No. 1.	5	0	No. 5.	10	0
2.	5	6	6.	14	0
3.	6	6	7.	18	0
4.	8	0	8.	26	0

Common ditto 8*d.* per lb.

LOCKS.

Rim Locks with Brass Knobs, complete.			*Drawback for Street Doors.*		
	s.	*d.*		*s.*	*d.*
6 inch . each	2	6	8 inch . each	4	6
7 „ . „	3	6	9 „ . . „	6	0
8 „ . „	5	0	10 „ . „	10	0

MORTICE LOCKS.

Without furniture, from 3*s.* 6*d.* to 6*s.* each.
Brass furniture to ditto, 2*s.* per set.
China „ from 2*s.* upwards.
Cupboard Locks, from 6*d.* to 2*s.* 6*d.* each.

GARDEN ROLLERS, MOUNTED.

		s.	*d.*			*s.*	*d.*
14 inches wide	each	23	0	22 inches wide	each	64	0
16 „ .	„	29	0	24 „ .	„	78	0
18 „ .	„	36	0	26 „ .	„	99	0
20 „ .	„	50	0				

HAY RACKS, from 7*s.* to 9*s.* each.

PILLARS FOR CORN STACKS.

		s.	*d.*			*s.*	*d.*
Octagon .	each	10	6	Feathered .	each	9	6

Circular, 6*s.* each.

PIPES, GUTTERING, &c.

	2 inches		2½ inches		3 inches		3½ inches		4 inches		4½ inches		5 inches		5½ inches	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Pipes for Rain Water	1	3	1	6	1	10	2	3	2	6	2	9	3	3		per yard.
Flat Heads	2	0	2	3	2	6	2	9	3	0	3	6	4	3		each.
Angle Heads . . .	2	3	2	6	2	9	3	0	3	3	4	0	4	6		„
Angle Shoes . . .	1	0	1	3	1	6	1	9	2	6	3	0	3	6		„
Angle Boots . . .	1	6	2	0	2	6	3	0	3	6	4	0	4	6		„
Guttering, half round					1	0	1	1	1	2	1	4	1	6	1	9 per yard.
Guttering, long angles					1	3	1	6	1	9	2	0	2	3	2	6 each.
Guttering, O.G. . .									1	7	1	8	2	2	2	6 per yard.
Guttering, O.G. angles									1	10	2	3	2	6	3	0 each.
Guttering, Lion Head Clips.									0	10						each.
Ditto, plain ditto . .									0	8						„
Flange pipes for pumps	3	0	3	6	4	3										per yard.
Pumps, various . .			35	0	45	0	55	0								each.

SECT. VI.—*Prices of Materials for Drainage and Water Supply.*

GLAZED STONE WARE DRAIN PIPES.

			s.	d.
3 inches	internal diameter	per foot run	0	5
4 „	„	„	0	6
6 „	„	„	0	8
9 „	„	„	1	1½
12 „	„	„	1	10
15 „	„	„	3	0
18 „	„	„	4	0

BENDS.

			s.	d.
3 inches	internal diameter	each	1	3
4 „	„	„	1	9
6 „	„	„	2	3
9 „	„	„	3	6
12 „	„	„	5	6
15 „	„	„	8	0
18 „	„	„	10	6

JUNCTIONS.

			s.	d.
3 inch	bore of main tube	each	1	3
4 „	„	„	1	6
6 „	„	„	2	0
9 „	„	„	3	6
12 „	„	„	5	6
15 „	„	„	8	0
18 „	„	„	10	6

DOUBLE JUNCTIONS.

			s.	d.
3 inch	bore of main tube	each	1	8
4 „	„	„	2	0
6 „	„	„	2	8
9 „	„	„	4	6

TRAPS FOR IRON FLAP.

			s.	d.
3 inch	bore	each	1	3
4 „		„	1	6
6 „		„	2	0
9 „		„	3	3

SYPHON TRAPS.

			s.	d.
3 inch	bore	each	2	6
4 „		„	3	6
6 „		„	5	0
9 „		„	7	6

Water Closet Pans, with Syphon Traps, from 7*s.* 6*d.* each.

NOTE.—Very large discounts are given by the pipe manufacturers for cash payments.

The Prices, Numbers, Sizes, and Weights, in Cast Iron, of LOWE'S *Patent Effluvia Trap Sewer Gratings, or Stench Trap Grids, are as follow, viz.:—*

	In.	In.	In.	Weight.	£	s.	d.
No. 1 Size	30	by 18	—16	deep, about 5 cwt.	1	18	0
No. 2 Size	20	by 12	—13	deep, about 2 cwt.	0	16	0
No. 3 Size	14	by 9	— 9	deep, about 1 cwt.	0	9	0
No. 4 Size	11	by 7	— 7	deep, 56lbs.	0	6	9
No. 5 Size	9	by 5½	—5½	deep, 25lbs.	0	4	0
No. 6 Size	6½	by 4	— 4	deep, 10lbs.	0	3	0
No. 7 Size for Sink Stones, in white metal, square pattern					0	2	6
No. 7 Size for Sink Stones, in iron, square pattern, with brass grating and screw plug					0	1	9
Ditto	ditto			in iron, round pattern, with brass grating and screw plug	0	2	0
Ditto	ditto			all brass, square pattern, with screw plug	0	3	6
Ditto	ditto			all brass, round pattern, with ditto	0	3	9
Ditto	ditto			brass top and grating and lead body, with screw plug	0	3	0

Glazed or unglazed draining bricks patented by Messrs. RANDELL and SAUNDERS, can be supplied at the following prices, in any locality where clay of good quality can be obtained.

BRICKS 12 inches long, 4½ inches wide, and 2½ inches thick, 1*d.* each.
,, 12 ,, 4½ ,, 3½ ,, 1½*d* ,,

The Cost of Bricks to make Drains of various dimensions will be as follows:—

Diameter of Drain.		No. of Bricks per foot.	Thickness of Brick.	Cost per foot.	
ft.	in.		in.	s.	d.
0	6	4	1¾	0	4
0	9	6	2	0	6
1	0	8	2¼	0	8
1	3	10	2½	0	10
1	6	12	2¾	1	0
1	9	14	3	1	9
2	0	16	3¼	2	0
2	3	18	3½	2	3
2	6	20	3¾	2	6
2	9	22	4	2	9
3	0	24	4¼	3	0

IRON SINK TRAPS.

ROUND JAPANNED TRAPS.

	per doz. s.	d.		per doz. s.	d.
2½ inch	4	0	6 inch	12	0
3 „	4	6	6½ „	13	6
3½ „	5	6	7 „	15	0
4 „	6	6	7½ „	16	6
4½ „	7	6	8 „	18	0
5 „	9	6	9 „	21	0
5½ „	11	0	10 „	26	0

SQUARE JAPANNED TRAPS, WITH BARS OR ROUND HOLES.

	per doz. s.	d.		per doz. s.	d.
4 inch	9	0	7 inch	18	0
5 „	11	0	8 „	23	0
6 „	14	0	9 „	28	0

STABLE DRAINS, JAPANNED.

		s.	d.			s.	d.
6 inch square	each	0	10	10 inch square	each	2	3
8 „	„	1	6	12 „	„	3	6

STRONG GRATES AND FRAMES FOR GRAVEL WALKS,

7 inch square at top, 3s.

SOUGH GRATES, JAPANNED.

	per doz. s.	d.		per doz. s.	d.
4 inch square	2	0	8 inch square	8	6
5 „	3	0	9 „	12	0
6 „	4	6	10 „	15	0
7 „	6	6			

STRONG SOUGH GRATES WITH BARS, JAPANNED.

	per doz. s.	d.		per doz. s.	d.
4 inch square	3	0	8 inch square	9	6
5 „	4	0	9 „	13	0
6 „	5	6	10 „	16	0
7 „	7	6			

SECT. VII.—*Plumber's Prices.*

	£	s.	d.
Milled lead in sheet, per cwt.	1	8	0
Cut to dimensions	1	9	0
Window lead	1	17	0
Laying Milled lead in gutters, flats, hips, or ridges	1	13	0
Do. in step or other flashings	1	15	0
D S or P traps, each	0	18	0
Strong service boxes, each	0	10	0
Safes for closets and straps	0	8	0
Solder, per lb.	0	0	10
Plumber, per day	0	6	0
Labourer, Do.	0	4	0
Wall hooks, each	0	0	1½
Lead-headed nails	0	0	1
Large do.	0	0	2
Allow for old lead in exchange, 4lbs. to be deducted for waste, per cwt.	0	6	0

	DRAWN WATER PIPES.	Middling. s.	d.	Strong. s.	d.
½ inch	per foot	0	5	0	6
¾ ,,	,,	0	7	0	8
1 ,,	,,	0	9	0	10
1¼ ,,	,,	0	11	1	1
1½ ,,	,,	1	3½	1	7
2 ,,	,,	1	10	2	3
2½ ,,	,,	2	3	2	8

	FUNNEL PIPES.	6 lbs.	7 lbs.
4 inch	per foot	2 4	2 9
4½ ,,	,,	2 9	3 0
5 ,,	,,	3 0	3 4
5½ ,,	,,	3 4	3 8
6 ,,	,,	3 8	4 0
4 inch joints	each		4 3
4½ ,,	,,		4 6
5 ,,	,,		5 0
5½ ,,	,,		5 6
6 ,,	,,		6 0
6½ ,,	,,		6 6

	SOCKET PIPES FOR SINKS.				
2 inch	per foot	1	5	1	7
2½ ,,	,,	1	7	1	9
3 ,,	,,	2	0	2	3
3½ ,,	,,	2	3	2	6

RAIN WATER PIPES, INCLUDING FLAPS AND COLLARS.

			s.	d.	s.	d.
3	inch	per foot.	2	0	2	3
3½	,,	,,	2	3	2	6
4	,,	,,	2	6	2	9

JOINTS, INCLUDING SOLDER AND LABOUR.

			£	s.	d.
½	inch	each	0	2	6
¾	,,	,,	0	2	9
1	,,	,,	0	3	0
1¼	,,	,,	0	3	3
1½	,,	,,	0	3	9
2	,,	,,	0	4	3
2½	,,	,,	0	4	9

COMMON LEAD PUMPS.

2½	inch	complete	1	12	0
3	,,	,,	2	5	0
3½	,,	,,	2	15	0
4	,,	,,	3	5	0

FORCE LEAD PUMPS.

2½	inch	complete	3	0	0
3	,,	,,	4	0	0
3½	,,	,,	4	15	0
4	,,	,,	5	15	0

HYDRAULIC PUMPS.

2	inch	complete	4	15	0
2½	,,	,,	5	10	0
3	,,	,,	7	0	0
3½	,,	,,	8	0	0
4	,,	,,	9	10	0

PUMPS FOR DEEP WELLS.

2½	inch	complete	4	15	0
3	,,	,,	5	15	0
3½	,,	,,	6	15	0
4	,,	,,	7	15	0

WATER CLOSETS.

	£	s.	d.
Best pan closet with valve, complete	2	5	0
Do. with sunk ivory handle	2	15	0
Do. with shoe valve, extra	0	4	0
Blue painted basin, extra	0	4	0
Bramah's valve closet, complete	5	10	0
Ship Closet with copper basin, complete	4	10	0

STOP COCKS.

Square way

½ inch	0	3	0
¾ „	0	4	0
1 „	0	7	6
1¼ „	0	10	6
1½ „	0	15	6
Large cocks, per lb.	0	2	0

BIB AND BALL COCKS.

Screw ferrules

½ inch	0	3	6
¾ „	0	4	3
1 „	0	8	0
1¼ „	0	11	6
1½ „	0	18	0

BOSSES, EACH.

½ inch	0	0	10
¾ „	0	1	0
1 „	0	2	0

COPPER WATER BALLS.

Wrought Rods.

For ½ inch cock	0	2	0
„ ¾ „ „	0	2	4
„ 1 „ „	0	4	3
„ 1¼ „ „	0	7	0
„ 1½ „ „	0	9	0

DRIVING FERRULES.

½ inch	0	1	1
¾ „	0	1	4
1 „	0	2	3
1¼ „	0	3	6
Cobourgs	0	3	6

LEAD AIR TRAPS,

With Brass Bell Grates.

	£	s.	d.
2½ inch	0	2	3
3 „	0	2	9
3½ „	0	3	6
4 „	0	4	6

BRASS GRATES.

1½ inch	0	0	4
2 „	0	0	5
2½ „	0	0	6
3 „	0	0	8
3½ „	0	0	10
4 „	0	1	0
4½ „	0	1	2
5 „	0	1	6

WASHERS AND WASTES, OR PLUGS.

¾ inch	0	1	9
1 „	0	2	9
1¼ „	0	3	9
1½ „	0	4	9
2 „	0	7	0
2½ „	0	12	0
3 „	0	18	0

SHORT SPINDLE VALVES.

¾ inch	0	2	0
1 „	0	2	9
1¼ „	0	3	3
1½ „	0	4	0
2 „	0	6	0
3 „	0	13	0

LONG SPINDLE VALVES.

1½ inch	0	6	0
2 „	0	8	0
2½ „	0	12	0
3 „	0	16	0

SUNDRIES.

Plain pan closet basin	0	9	0
Hopper „	0	11	0
Blue painted basin	0	14	0

	£	s.	d.
Fan and mounting basin	0	3	0
Wash-hand basin with brass washer and chain	0	6	6
Blue printed do.	0	8	6
Copper tinned basins	0	4	6
Round cistern valves	0	5	9
Shoe do.	0	10	6
Spring do.	0	10	6
Spring board and spring	0	6	6
Cranks each	0	1	0
Stool cocks with plates and handle	0	7	6
Copper wire, per lb.	0	1	8

BOILER SCREWS.

½ inch	0	1	3
¾ „	0	1	8
1 „	0	2	6
1¼ „	0	3	6
1½ „	0	4	3

COCKS FOR SLATE CISTERNS.

½ inch	0	4	3
¾ „	0	5	6
1 „	0	10	0

SCREWS WITH NUTS AND UNIONS FOR SLATE CISTERNS.

½ inch	0	3	4
¾ „	0	4	9
1 „	0	6	6

WASHERS AND WASTES FOR SLATE CISTERNS WITH UNIONS.

½ inch	0	2	9
¾ „	0	5	6
1 „	0	7	6

SPINDLE VALVES FOR SLATE CISTERNS WITH UNIONS.

¾ inch	0	5	9
1 „	0	7	6

Sect. VIII.—*Painter's Prices.*

COMMON COLOURS, INCLUDING KNOTTING AND STOPPING.

			s.	d.
Once in	oil	per yard	0	3½
Twice in	„	„	0	6
Three times in	„	„	0	8
Four times in	„	„	0	10
Add to every extra coat		„	0	2
If flatted	„	„	0	3½
If finished in party colours, add		„	0	1½
If sanded	do.	„	0	6

EXTRA COLOURS.

French grey, fawn, salmon, peach, or like tints	add	0	1
Light green, or olive green	„	0	3
Patent greens, French greens, yellows or blues	„	0	6
Chinese Vermilion or Lakes	„	1	9
„ twice done on scarlet ground	„	2	9
Imitation granite or splashed work	„	0	6
Mouldings cut in, per foot run, common colours		0	0½
„ if grained in imitation of woods	per foot	0	2
Broad lines to form panels	„	0	1½
Light and shadowed lines	„	0	2
Cross banded margins	„	0	3½

PLAIN SKIRTINGS, NOT EXCEEDING EIGHT INCHES WIDE.

Once in	oil	per foot run	0	0¾
Twice	„	„	0	1¼
Three times	„	„	0	1¾
Four times	„	„	0	2¼
If flatted, add		„	0	0½

MOULDED SKIRTINGS, EXCEEDING EIGHT INCHES WIDE.

Once in	oil	per foot run	0	1
Twice	„	„	0	1½
Three times	„	„	0	2
Four times	„	„	0	2½
If flatted, add		„	0	½

PLAIN CORNICES, NOT EXCEEDING TWELVE INCHES GIRT.

Once in	oil	per foot run	0	1¼
Twice	„	„	0	1¾
Three times	„	„	0	2½
Four times	„	„	0	3
If flatted, add		„	0	1

ENRICHED CORNICES, FRIEZES, OR OTHER ENRICHMENTS.

		s.	d.
Once in oil	per foot super.	0	1½
Twice „	„	0	2¼
Three times „	„	0	3½
Four times „	„	0	5
If flatted, add	„	0	6

If picked in party colours add one half.

REVEALS TO WINDOWS AND DOORS.

		s.	d.
Once in oil	per foot run	0	1¼
Twice „	„	0	1¾
Three times „	„	0	2½
Four times „	„	0	3

WINDOW SILLS, STRINGINGS, COPING EDGES, PLINTHS, &c.

		s.	d.
Once in oil	per foot run	0	2¼
Twice „	„	0	3½
Three times „	„	0	5
Four times „	„	0	6

RAIN WATER PIPES AND GUTTERS.

		s.	d.
Once in oil	per foot run	0	1¾
Twice „	„	0	2½
Three times „	„	0	3
Four times „	„	0	3½

SASH FRAMES AND SQUARES.

		s.	d.
Frames once in	oil, not exceeding 25 feet super.	0	8
Do. twice	„ „	1	0
Do. three times	„ „	1	4
Do. four times	„ „	1	8
For large Venetian frames, add one-third			
Sash squares	per dozen once	0	8
Do.	„ twice	1	0
Do.	„ three times	1	4
Do.	„ four times	1	8
If the squares exceed 30 inches, add per doz. each coat		0	3
If different colour from the frames, add		0	1
If flatted, add		0	4

SASH FRAMES AND SQUARES, GRAINED.

		s.	d.
Wainscot oak or mahogany frames, each		1	6
Do.	squares per doz.	1	6

		s.	d.
Rosewood, satinwood, maple, &c.	squares per doz.	2	0
Varnishing squares per doz. or frames each, in copal		0	6

Cleaning old work, rubbing down, or bringing forward, &c., to be charged day work, ladder work to be charged extra, according to trouble and labour. The term, party colours, is applied where the framing is one colour and the panels another.

DAY ACCOUNT.

Painter, per day		6	0
Common colour	per lb.	0	6
Putty	„	0	3
Hard stopping	„	0	6
Brushes	each	3	6
Tools	„	1	4
Pots	„	0	6
Small do.	„	0	4

IMITATIONS OF WOODS AND MARBLES*.

Wainscot oak	per yard	1	6
Mahogany, maple, or sycamore	„	1	9
Rosewood or Coromandel-wood, and satinwood	„	2	0
Bird's-eye maple or pollard oak		2	6
For enrichments and carved work, add one-fourth			
Hand-rail, grained mahogany and varnished	per foot run	0	4
Veined marble, including white ground	per foot super.	0	3
Dove, bardilla, or black and gold	„	0	5
Sienna, brocatella, Venetian, French, Devonshire	„	0	6
Green verd, or porphyry	„	0	6
Verd antique, oriental, jasper, giolla antico	„	0	8
Lapis lazuli	„	1	0
If to columns, add	„	0	3
If to fluted do., add	„	0	4

VARNISHING.

Spirit varnish, each coat	per yard	0	6
Varnishing once in best copal	„	0	7
Do. twice do.	„	1	0
Do. three times do.	„	1	4
Cleaning and sizing old work	„	0	8
Hand polishing, per foot super		0	6
Do. on columns	„	1	0
Do. do. fluted	„	1	6
French polishing	„	0	6
Do. hand-rails and small articles, per foot run		0	4

* The prices here given are for work of the very best quality.

WRITING.		£	s.	d.
Plain letters	per inch	0	0	0½
Do. from 3 to 6 inches girt	„	0	0	2½
Sunk or Egyptian	„	0	0	1
Gold plain, under 3 inches girt	„	0	0	1½
Gold sunk or Egyptian do.	„	0	0	2
Gold plain, from 3 to 6 inches girt	„	0	0	2
Gold plain, from 6 to 9 do.	„	0	0	2½
Gold plain, from 9 to 12 do.	„	0	0	3
Gold Egyptian, from 6 to 9 inches girt	„	0	0	3
Gold do. from 9 to 12 do.	„	0	0	4
If shadowed, add	„	0	0	0½
If do. double or indented, add	„	0	0	0¾
If shaded to appear as projecting letter, add for the double shadow		0	0	1
Letters enamelled in gold on glass, per inch		0	0	3

Antique or ornamental letters, once and a half the above prices.

GILDING.				
Gilding in oil gold, including preparation, per foot super.		0	3	6
Do. in burnished gold		0	4	6
Carved work, from once and a half to double the above prices, according to the depth of the enrichment.				
Gilding ½ inch mouldings, per foot run		0	0	2
Do. ¾ do. „ „		0	0	3
Do. 1 do. „ „		0	0	4
Gilder per day		0	7	0
Gold leaf per book		0	2	0
Parchment size per lb.		0	0	8
Oil gold size do.		0	3	0

SECT. IX.—*Paperhanger and Decorator's Prices.*

Pumicing, sizing, and preparing walls,	per piece	0	0	6			
Lining paper	„	0	0	9			
Do. stout	„	0	1	0			
Canvas lining	„	0	3	6			
Hanging do., including tacks and slipping	„	0	1	6			
Hanging lining paper	„	0	0	9			
Do. common papers	„	0	1	0			
Do. satin do.	„	0	1	2			
Do. flock or embossed, marbles or granites in blocks	„	0	1	6			
Common papers, 3 colours, or two blocks, per piece	0 1 0 to	0	2	0			
Do. do. 4 do.	„ 0 2 0	0	2	6			
For every extra colour, add	„	0	0	2			
If in rich colours, add	„	0	1	0			

	£	s.	d.		£	s.	d.
Imitation marble . . per piece	0	1	6	to	0	2	6
Do. do. done by hand in a superior manner	0	4	6	„	0	8	0
Do. granite posted . . „	0	2	0	„	0	4	0
Do. wainscot . . . „	0	1	0	„	0	1	6
Do. do. overgrained . . „	0	2	6	„	0	3	6
Satin papers, 3 blocks . . „	0	4	0	„	0	6	0
Do. do. 5 do. . . . „	0	6	0	„	0	10	0
Embossed satin . . . „	0	8	0	„	0	10	0
Do. do. bronzed . . „	0	12	0	„	0	15	0
Rich crimson flock . . „	0	14	0	„	0	18	0
Do. do. bronzed . . „	0	18	0	„	1	5	0
Panelled decoration . . . „	0	9	0	„	1	16	0
Do. do. including hanging . „	0	11	0	„	2	0	0
Common borders, per dozen yards . .	0	1	0	„	0	3	0
Gothic do. . .	0	6	0	„	0	8	0
Corners to do., each as one yard of border.							
Hanging borders, per dozen yards . .	0	0	6	„	0	1	0
Sizing two coats, and varnishing papers per piece	0	2	6	„	0	3	6
Do. do. and do. two coats .	0	4	0	„	0	6	0

BORDERS AND MOULDINGS, INCLUDING HANGING AND PAPER FIXING.		MOULDING.					
		Black polished		Black gold.		Gold.	
	s. d.	s.	d.	s.	d.	s.	d.
Half-inch wide, . per yard run . .		0	3	0	6	0	9
Five-eighths wide, . „ . .		0	3	0	7	0	10
Three-quarters wide, . „ . . .	0 0¼	0	3½	0	9	1	0
Inch wide, . . . „ . .	0 0½	0	4½	0	11	1	2
Inch and quarter wide, „ . . .	0 0¾	0	6	1	1	1	6
Inch and half wide, . „ . .	0 1	0	7	1	2	1	9
Inch and three-quarters wide, „ . . .	0 1¼	0	8	1	4	2	0
Two inches wide, . „ . .	0 1½	0	10	1	8	2	4
Rich flock borders, 2½ inches wide, . . .	0 3						
Do. 3½ do. . . .	0 4						
Old mouldings, up to one inch girt, taken down regilt and refixed, per yard . . .						1	0
For every ¼ inch extra width, add . . .						0	2
Ebon lines, drawn out in panels, per foot . .						0	0½
Light and shadowed lines, „ . .						0	1
Do. with shaded margin, 3 inches wide . .						0	2
SCAGLIOLA.							
Gray Granite or Porphyry, on slate, per foot						5	6
Statuary, black and gold . . „						6	0
Sienna, Verana, Giallo antico, or Rondara „						7	0
Brocadilla, or Egyptian green . . „						7	6
Verd Antique, or Lapis Lazuli . „						8	0
Columns, including skeleton, extra . „						1	0

DISTEMPERING.

		Once.		Twice.	
		s.	*d.*	*s.*	*d.*
Washing, stopping, and whitening	per yard	0	3½	0	5
,, cream tint	,,	0	4	0	6
,, drab, fawn, grey	,,	0	5	0	8
,, green, lilac, or peach blossom	,,	0	8	0	10
,, pea green or light blue with verditer	,,	1	0	1	4
,, clouded ceilings	,,	2	0		
If one coat of oil color add	,,	0	2		
Ditto in turps	,,	0	3		

Plain cornices per foot super., half the above prices.
Enriched ditto, two-thirds.

SECT. X.—*Glazier's Prices.*

CROWN GLASS IN NEW SASHES.

At per foot super.

	Best.		Seconds.		Thirds.		Fourths.		Best Ground.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Squares from 3 ft. 0 in. to 3 ft. 6 in.	1	4	1	2	1	1	0	9	2	0
,, 2 6 ,, 3 0	1	2	1	1	0	11	0	8	1	10
,, 2 0 ,, 2 6	1	0	0	11	0	9	0	7	1	8
,, 1 6 ,, 2 0	0	11	0	10	0	8	0	6½	1	6
,, under the above . . .	0	9	0	8	0	7	0	5½	1	3

For flatted glass add one third, and for bent two thirds to the above.

PATENT PLATE GLASS IN SQUARES FOR GLAZING.

At per foot super.

	BEST.							
	No. 1.		No. 2.		No. 3.		No. 4.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
6 by 4 and under 9 by 7 . .	1	2	1	3	1	4	1	5
9 by 7 and not above 10 by 8 . .	1	3	1	4	1	5	1	6
10 by 8 ,, 1 ft. . .	1	8	1	10	2	0	2	2
1 ft. ,, 1½ ft. . .	1	11	2	0	2	2	2	4
1½ ft. ,, 2 ft. . .	2	2	2	4	2	6	2	9
2 ft. ,, 3 ft. . .	2	4	2	7	2	9	2	11
3 ft. ,, 4 ft. . .	2	6	2	9	2	11	3	1
4 ft. ,, 8 ft. . .	3	0	3	3	3	0	3	0
8 ft. ,, 10 ft. . .	3	3	3	6	3	9	4	0
10 ft. ,, 12 ft. . .	3	6	3	9	4	0	4	3

For seconds up to 1 foot 6 inches deduct 1*d.* and for all above that size 3*d.*
No. 1 averages 1-16th of an inch, in thickness and 13 oz. weight to the foot.
No. 2 „ 1-12th „ 17 „
No. 3 „ 1-10th „ 21 „
No. 4 „ 1-9th „ 24 „

COLOURED GLASS.

		Best.		Seconds.	
		s.	*d.*	*s.*	*d.*
Yellow and lemon,	per foot super.	2	6	1	9
Orange, blue, purple and red	„ .	3	3	2	3
Green, flashed ruby, and blue	„ .	3	9	3	0
Embossed glass from	„ .			2	6
Rosettes per inch	„ .	0	8		

CROWN GLASS STOPPED IN OLD SASHES.

	Best.		Seconds.		Thirds.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*
In squares 3 ft. 0 in. to 3 ft. 6 in. per foot super.	2	0	1	8	1	3
Ditto 2 6 „ 3 0 „	1	8	1	5	1	2
Ditto 2 0 „ 2 6 „	1	5	1	3	1	1
Ditto under 2 0 „	1	3	1	1	1	0

HORTICULTURAL GLASS, IN LIGHTS, GLAZED.

	13 oz.		16 oz.		21 oz.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*
Not above 12 in. long, and 10 in. wide, per foot super.	0	4½	0	5	0	7
Do. 3 ft. super., and not above 40 in. long .	0	5	0	6	0	7½
FLUTED GLASS, GLAZED.						
10 in. by 8 in., and not above 1½ ft. per ft. super.	1	0	1	1	1	5
1½ ft. do. 2 „ . „ .	1	1	1	3	1	7
2 „ do. 2 ft. 6 in. „ .	1	4	1	6	1	11
2½ „ do. 3 „ . „ .	1	5	1	7	2	3
Best flattened crown glass, per foot super., extra .					0	4½

POLISHED PLATE FOR GLAZING PURPOSES.

	£.	s.	d.
Under 1 superficial foot . . . per foot	0	1	9
1 ft. and under 2 feet „	0	2	3
2 ft. „ 3 ft. „	0	2	6
3 ft. „ 4 ft. „	0	2	9
4 ft. „ 6 ft. „	0	3	0
6 ft. „ 8 ft. „	0	3	3
8 ft. „ 10 ft. „	0	3	6
10 ft. „ 12 ft. „	0	3	8
12 ft. „ 14 ft. „	0	3	10
14 ft. „ 16 ft. „	0	4	0
16 ft. „ 18 ft. „	0	4	2
18 ft. „ 20 ft. „	0	4	4
20 ft. „ 25 ft. „	0	4	6
25 ft. „ 30 ft. „	0	4	9
30 ft. „ 35 ft. „	0	4	11
35 ft. „ 40 ft. „	0	5	2
40 ft. „ 45 ft. „	0	5	5
45 ft. „ 50 ft. „	0	5	8
50 ft. „ 55 ft. „	0	5	10
55 ft. „ 60 ft. „	0	6	0
60 ft. „ 65 ft. „	0	6	3
65 ft. „ 70 ft. „	0	6	6

Glazing 4*d.* per foot extra.
Ground edges 6*d.* per foot run.

ROUGH PLATE GLASS.

At per foot super.

	¼ inch.		½ inch.		¾ inch.		1 inch.		1¼ inch.		1½ inch.		2 inches.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Not above 15 in. long .	0	11	1	5	3	0	4	6	5	3	6	0	8	6
Above 15 in. and not above 35	1	0	1	6	3	4	5	0	6	0	7	0	10	0
„ 35 „ 75	1	3	2	0	4	0	6	0	7	0	8	0	11	0
„ 75 „ 100	1	5	2	1	4	6	7	0						
„ 100 and upwards.	1	6	2	6	5	0								

If ground on one side add 6*d.* per foot.
If smooth on one side and polished the other 2*s.*
Bending rough plate 2*s.* per foot.
Do. polished plate 3*s.*

For silvering plate glass add one fifth and for embossing do. 5*s.* per foot super. on squares not exceeding 6 feet.

HARTLEY'S PATENT ROUGH PLATE GLASS, INCLUDING GLAZING.

At per foot super.

	THICKNESS.									
	$\frac{1}{8}$		$\frac{3}{16}$		$\frac{1}{4}$		$\frac{3}{8}$		$\frac{1}{2}$	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Under 3 ft. superficial	0	8	0	10	0	11	1	1	1	2
„ 4 „	0	9	0	11	1	0	1	2	1	4
„ 5 „	0	10	0	11	1	1	1	3	1	5
„ 6 „	0	11	1	0	1	2	1	4	1	6
„ 10 „	1	0	1	1	1	3	1	5	1	7
„ 12 „	1	0	1	1	1	4	1	6	1	8
„ 15 „	1	0½	1	2	1	5	1	7	1	9
„ 20 „	1	1	1	3	1	6	1	8	1	10
„ 25 „			1	4	1	7	1	9	1	11
„ 30 „					1	8	1	10	2	0
Quarries, „	0	10	0	11						

SUNDRIES.

	£	*s.*	*d.*
New lead lights with squares 6 in. by 4 in., per ft. super.	0	0	11
Do. do. to 10 by 8 „	0	1	1
If with quarries add one fourth.			
Quarries stopped in old lead lights each „	0	0	2
Squares under 7 by 5 „	0	0	3
„ 7 by 5 and under 8 by 6 „	0	0	5
„ 9 by 7 and under 10 by 8 „	0	0	8
New leading old lights, per foot super. „	0	0	10
Repairing and part leading do. „	0	0	6
Casements pinned in each „	0	0	8
Puttying windows or skylights, each side, per doz. squares	0	0	2
Cleaning windows per dozen squares common size	0	0	6
Do. „ large	0	1	0
Moore's moveable glass louvre ventilators, zinc frames and levers, brass rivets, 16 oz. sheet glass, rough edges, per foot	0	8	0
Do. 21 oz. sheet glass, rough edges per foot	0	10	0
Do. patent plate, ground edges „	0	16	0
Brass frames and levers, British plate, ground and polished edges	1	3	0

	THICKNESS.									
	$\frac{1}{16}$ inch.		$\frac{1}{8}$ inch.		$\frac{1}{4}$ inch.		$\frac{3}{8}$ inch.		$\frac{1}{2}$ inch.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Glass tiles, each . . .	0	8	1	0	1	6	2	0	2	6
Do. slates, each 24 in. by 2 in. .	1	10	2	0	3	10	4	6	5	6
Do. do. 20 „ 10 „ .	1	0	1	5	2	9	3	3	3	10
Do. do. 16 „ 8 „ .	0	10	1	3	2	0	2	4	2	9

SECT. XI.—*Zinc Worker's Prices.*

Malleable zinc laid with rolls, including labour to laying, complete.

	GAUGE.													
	No. 10		11		12		13		14		15		16	
Weight per foot superficial	14 oz.		16 oz.		18 oz.		21 oz.		24 oz.		26 oz.		30 oz.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Flats, „	0	5	0	5½	0	6	0	6½	0	7	0	8	0	9
Verandahs, „	0	6	0	7	0	7½	0	8	0	8½	0	9½	0	10½
Gutters, „	0	5½	0	6	0	6½	0	7	0	7½	0	8½	0	9½

GUTTERS AND RAIN WATER PIPES.

At per foot run.

	DIAMETER.													
	Gutters.		O. G. Gutter.		Pipes.		Square Heads, each.		O. G. Heads, each.		Octagon Heads, each.		Shoes each.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
2 inches . . .					0	3½	2	0	2	9	3	8	1	4
2½ „ . .					0	4	2	6	3	6	4	8	1	7
3 „ . . .	0	3½	0	5	0	5	2	9	4	3	5	4	2	0
3½ „ . .	0	4	0	5½	0	5½	3	3	4	9	5	9	2	4
4 „ . .	0	4½	0	6½	0	6	3	10	5	3	6	3	2	8
4½ „ . .	0	5	0	7	0	7	4	2	6	0	6	9	2	10
5 „ . . .	0	5½	0	7½	0	7½	4	10	6	6	7	3	3	2

	DIAMETER.					
	10 inch.		11 inch.		12 inch.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*
Chimney pipes, per foot	2	6	2	9	3	0
Malthouse cowls, each	4	6	5	6	6	6
Lobster back cowls, each	6	6	7	6	8	6
Smoke dispersers	7	6	8	0	9	0

SUNDRIES.

		£	*s.*	*d.*
Perforated plates	per foot super.	0	0	4½
Do. fitted into squares	,,	0	0	6
Metal skylights and fan lights	,,	0	2	6
Do. large stout made	,,	0	3	0
Ventilating tops according to size up to		1	5	0
Bell tubing, verandah caps and roles	per lb.	0	0	6
Fan light and skylight bar	,,	0	0	7
Zinc nails for slates	,,	0	0	7
Do. tacks	,,	0	1	0
Soft solder	,,	0	0	10
Zinc worker	per day	0	6	0
Labourer	,,	0	4	0
Plumbic zinc,	per cwt.	1	14	0

GALVANIZED TINNED IRON,

Per Square.

Plain galvanized tinned iron for roofs or flats laid complete with	No. 28 gauge	2	0	0	
Do.	24 ,,	2	8	0	
Do.	22 ,,	2	16	0	
Straight corrugated	24 ,,	2	12	0	
Do. ,,	22 ,,	2	18	0	
Do. ,,	20 ,,	3	5	0	
Do. ,,	18 ,,	3	18	0	
Curved ,,	24 ,,	2	15	0	
Do. ,,	22 ,,	3	3	0	
Do. ,,	20 ,,	3	15	0	
Do. ,,	18 ,,	4	0	0	
Do.	16 ,,	4	18	0	

STEAM AND GAS FITTINGS EXCLUSIVE OF FIXING.

	2 inch.	1½ inch.	1¼ inch.	1 inch.	¾ inch.	½ inch.	⅜ inch.	¼ inch.	⅛ inch.
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Patent wrought iron welded tubing, per ft.	1 9	1 1	0 11	0 8	0 6	0 5	0 4½	0 4	0 3½
Ditto galvanized „	2 1	1 4	1 2	0 10	0 8	0 7	0 6	0 5½	0 5
Bends and springs, wrought, each	3 10	2 4	1 10	1 1	0 11	0 9	0 8	0 7	0 6
Bends and elbows, „	3 6	2 0	1 9	1 0	0 9	0 8	0 6	0 5	0 4
T's equal & diminishing outlets, each	3 6	2 0	1 9	1 0	0 9	0 7	0 6	0 5	0 4
Crosses, equal outlets, „	4 3	2 9	2 6	1 9	1 6	1 2	1 0	0 9	0 9
Diminishing sockets or nipples, caps or plugs, & hexagon nuts, each	1 4	0 10	0 9	0 7	0 6	0 5	0 4	0 3	0 3
Plain sockets, „	1 0	0 8	0 7	0 6	0 5	0 4	0 3	0 2½	0 2
Connecting pipes or long screws, each	3 8	2 4	2 2	1 8	1 2	0 10	0 9	0 8	0 7
Iron cocks screwed to fit . each	18 0	11 0	9 0	5 6	4 6	3 0	2 6	2 0	1 9
Brass main cocks, „	44 0	18 0	13 0	8 0	5 0	3 0	2 6	2 0	
Flanges, „	1 10	1 7	1 3	1 0	0 10				
Stout tin pipe, per foot	2 9	2 0	1 4	1 0	0 9	0 7	0 6	0 5	
Union joints for metal pipes, . each					1 4	0 10	0 8	0 7	
Strong do. for iron „	10 0	6 0	4 9	3 3	2 3	1 8	1 4		

	£	*s.*	*d.*
3 light gas meters	2	0	0
5 do. do.	2	10	0
10 do. do.	3	0	0

SECT.—XII. *Coppersmith's Prices.*

Copper pipes for main water, with rings and tacks complete, per foot run :—			
2½ inch	0	1	2
3 „	0	1	8
3½ „	0	1	9
4 „	0	1	11
Copper gutters semicircular, arwired, complete :—			
6 inches girt, per foot run	0	1	0
8 „ „	0	1	3
10 „ „	0	1	6
12 „ „	0	1	9

Tinned do., 2*d.* to 3*d.* extra. Fixing extra.

	£	s.	d.
Spike and screw prepared with copper ties, 1*s.* to 1*s.* 6*d.* each.			
Copper cistern heads, from 7*s.* 6*d.* to 12*s.* 6*d.*			
12 oz. copper for flats and gutters, including seams, labour, ties, and nails, per ft. super.	0	1	3
16 oz. „ „ „	0	1	8
20 oz. „ „ „	0	2	0
For verandahs, add per foot	0	0	2

COPPER PIPES.

		Weight.	Price.		Joints each.	
		lbs.	*s.*	*d.*	*s.*	*d.*
2 inch	per foot run	1½	2	8	6	0
2½ „	„	1¾	3	8	6	8
3 „	„	2¼	4	0	7	0
3½ „	„	2½	4	6	7	6
4 „	„	3	5	4	9	0
4½ „	„	3½	6	4	11	0
5 „	„	4½	7	9	13	0
Sheet copper	per lb.		1	0		
Washing copper	„		1	8		

SECT. XIII.—*Wire Worker's Prices.*

	£	s.	d.
Iron wire for skylight per foot super.	0	1	1
Strong ditto, ½ inch mesh „	0	1	4
Fly wire for safes „	0	2	0
Copper do. „	0	3	9
Brass trellis wire for bookcases „	0	3	3
Octagon do. „	0	3	3
Strong brass trellis for window guard frames „	0	5	6
Fine wove wire for blinds „	0	1	6
Do. in mahogany frames, French polished, and painted	0	2	8
Do. with lines and ornamental corners	0	3	6
Extra for copper wire	0	1	2

CHAPTER XXI.

ON DILAPIDATIONS AND NUISANCES.

SECT. I.—*General Definitions.*

THE rights of parties with respect to immoveable property so closely border on each other, and the line of demarcation between them is so indistinct, that one man, in the fancied exercise of his right, is continually liable to encroach upon or disregard the right of another. No person, however absolute his property in land, can put it to any use he pleases; his right to use is restrained by the rights of his neighbour; he is bound to take care that his manner of using does not interfere with the inoffensive and profitable occupation by his neighbour of his land. Questions as to the mode in which lands should be used may arise, either between parties who have different rights to the same land, and between whom there is a privity or connection of interest as between landlord and tenant, tenant for life and remainderman, or incumbent of a benefice and his patron or successor, or between parties who are strangers to each other in respect of the land used, as the occupiers of two adjoining tenements. In cases where there is a privity in respect of the land, every defect in the condition of the land or house is termed a dilapidation, and the act or default of the tenant causing or permitting such defect is termed waste: in cases where tenements, from misuser or defect of repair, become injurious to a stranger, the act or default of the party is termed a nuisance. If a landlord complain that his tenant has dilapidated the premises leased, he must prove that the dilapidations in question are such as either the general nature of the tenure or the particular stipulations of the lease oblige the tenant to repair; but if the possessor of a house complain that his neighbour has obstructed his lights or injured his foundation, he must establish his right to the lights or foundation injured, and by so doing he proves the obligation of the neighbour not to infringe those rights. The

Distinction between Dilapidations & Nuisances.

party complaining of a dilapidation must show an original inherent qualification of the presumed absolute right of the party possessed; the party complaining of a nuisance has to prove either that the party complained of has exceeded his presumed absolute right, or has granted a portion of it to him, and has derogated from that grant.

Waste defined.

Waste may be defined as the act or default of one party, having a right to use a tenement to the injury of another, having a right to the same tenement.—Nuisances comprehend all nuisances which are the acts or defaults of the possessors of tenements to the injury of strangers, or of parties interested in the neighbouring tenements.

Nuisances defined.

Obligation to repair; to what Estates attached.

It is only where the right to use is limited in point of duration, and the right of the successor certain to take effect, that there can be any obligation to repair; thus tenant in fee simple and tenant in tail are under no obligation in this respect. It is not essential that the right of succession should be vested in any certain person, if there be a right of succession which is certain to take effect; thus, in the case of an ecclesiastical benefice, though the successor be not known until after the incumbent's estate is determined, he is under an obligation to repair, which the successor may enforce against him or his representatives.

Nature of Obligation to repair.

The obligation to preserve from dilapidations, resulting from the right to use, varies with the nature and extent of that right; different tenants being bound to different repairs, according to the nature of their estates, and the covenants and conditions to which they agree. To suffer dilapidations, is called Permissive Waste; and to do any act which will cause dilapidations, is, in legal language, to commit voluntary waste.

Distinction between Permissive and Voluntary Waste.

Alteration of Tenement.

The rule against Voluntary Waste includes an alteration in the tenement, although it be not thereby rendered less valuable, or even though the effect of the alteration be to increase the value.

Division of Waste.

Hence there are three species of waste,—permissive, voluntary, and malicious. Permissive waste is of five sorts: first, the neglect to repair the necessary effects of time and use; second, the neglect to repair the consequences of inevitable accident; third, the neglect to repair the external or internal coverings of a building; fourth, the omission to protect the fabric of the building from the consequences

of dilapidations in the coverings; and, fifth, the omission to prevent the wrongful act of a stranger. The obligations of parties with respect to dilapidations may be ranged into three classes.

Of the obligation to repair.

Of the first class, are the obligation to repair, of the incumbent, of an ecclesiastical benefice,—the obligation of the public to repair churches, highways, bridges, and sewers. The incumbent of a benefice receives the whole profits of the tenements of which the benefice is endowed, and is bound to supply the necessary effects of time and use, and the consequences of inevitable accidents, upon the buildings attached to the benefice.

Obligation of Ecclesiastics.

The public have the sole right to use churches, highways, bridges, and sewers, and they are all interested in having them kept in perfect repair. They must, at all events, keep them in such a state of repair as is necessary for the purposes for which they are required.

Of Public to repair Churches, Highways, &c.

Churches and highways are repairable by the inhabitants of the parish in which they are situate. The obligation is an obligation of the parishioners towards the public generally, who all have an interest in the support of churches and maintenance of highways; and there is also an obligation of each individual parishioner towards the general body, to contribute his proportion of the expense.

Bridges being maintained at a greater expense than ordinary highways, and not being situate in every parish, it tends more to the equality of the burden that the charge of repairing them should be borne by a larger district: for this reason, the law has imposed the obligation of repairing bridges upon the inhabitants of the county.

Bridges.

Sewers, which include sea walls, and every other erection or device for the protection of lands from the inundations of the sea or rivers, or for draining off land-waters, are not, like churches, highways, and bridges, beneficial to the public generally, but only the proprietors of particular levels, liable to be damaged by inundations, or requiring drainage. The inhabitants and proprietors of a level alone are bound to repair the walls and banks by which they are protected from floods, and the sewers by which they are drained; and this is, in its nature, an obligation of one proprietor towards the other proprietors, who are subject to a common danger or inconvenience,

Sewers.

and rather private than public, though common to many individuals.

Although the obligations to repair churches, highways, bridges, and sewers, are equally well ascertained, there is an observable difference as to the manner in which they are sanctioned. It is the duty of churchwardens to see that the church is repaired: but it is left to the parishioners themselves to determine what repairs shall be done, and the amount that shall be expended; if they deny their obligation, the votes of the majority denying the obligation to repair are considered as thrown away, and the votes of the minority who admit the obligation, prevail; and if they suffer the church to become dilapidated, they may be proceeded against by ecclesiastical censures. At common law, the repairs to be done to highways and bridges, and the amount to be expended, were equally under the control of the inhabitants of the parish or county; though, if they neglected to do sufficient repairs, they were and still are liable to an indictment. By statute, the repairs of highways are subject to the control of a surveyor, and those of bridges to the justices of the peace. The maintenance of sewers and sea walls was never voluntary, but was under the direction of commissioners of the Crown.

Obligation of Tenants for Life and Years.

The second class includes the obligation on all particular tenants, whose estate is less than an estate of inheritance, except ecclesiastical incumbents. The law relating to the general obligation of these tenants to repair is called the Law of Waste; the law relating to the obligation of ecclesiastics is called the Law of Dilapidations.

At common law only those tenants whose estates were created by law were liable for permissive waste in the absence of express stipulation. If the estate was created by the party, and there was no condition against waste, or covenant to repair, it was considered that it was not intended to place the tenant under any obligation to repair, and the case was presumed to be of the third class. The statute of Marlbridge has altered this presumption, and now tenants for life and for years, whether their estates are created by act of law or act of the party, are equally liable for waste, as well permissive as voluntary, unless it is expressly provided that they shall be without impeachment of waste.

In these cases, it being presumed that an equivalent for the occupation is given to the grantor, the tenants are not bound to repair the necessary and inevitable effects of time and use. Their obligation is to preserve the tenements from premature decay by reason of exposure to the weather, and for this purpose to repair the external and internal coverings of the fabric of the buildings. They are liable for permissive waste of the fourth sort.

Mortgagees. Mortgagees, who, although they have at law an absolute estate in the tenements mortgaged, are in equity deemed to hold them as a pledge merely, are in equity under a similar obligation to the mortgagors. Of course they are entitled to be allowed the sums expended in necessary repairs out of the profits of the premises.

Obligation by Covenant. The obligation of a tenant for life or years may be extended by express covenant. Such covenant is construed with reference to the common law obligation, and unless an intention to the contrary is manifest, does not render the tenant liable to repair the necessary effect of time and use, or the inevitable decay of the fabric of the building. In ordinary cases the obligation is against permissive waste of the third sort. They are also liable to repair dilapidations caused by inevitable accident.

Waste by Strangers. All tenants who are liable for permissive waste are responsible for waste committed by strangers, which it is presumed they are able to withstand, and against whom they have a remedy. If the strangers are the Queen's enemies, or felons, their acts of waste are in the nature of inevitable accidents, for which tenants for life and years, not under covenant to repair, are not liable.

Tenants without Impeachment of Waste, and Tenants at Will. In the third class may be ranged—tenants without impeachment of waste and tenants at will. Neither of these are liable for permissive waste,—the tenant without impeachment by reason of the expressed intention of the grantor of the estate; and the tenant at will by reason of the infirmity of his estate. An estate at will is, in contemplation of law, of no value; and therefore whatever services such tenant renders to his landlord, and it may be presumed that he renders some, must be more than an equivalent for his estate.

All tenants, except tenants without impeachment of waste are liable for voluntary waste; and tenants without impeachment of waste are liable in equity, but not at law,

Malicious Waste.

for malicious waste. Malicious waste consists in pulling down the mansion house, or felling timber planted for the ornament or protection of the mansion-house. The Court of Chancery considers that it was not the intention of the grantor to confer the power of destroying such things. From this waste being solely cognizable in Courts of Equity, it is called Equitable Waste.

Tenants in Common.

Questions respecting dilapidations occasionally arise between persons interested jointly or in common in tenements. In such cases there is no obligation by one to the other to repair any particular dilapidations. One tenant has a remedy against his co-tenant if he commit voluntary waste, and may compel him to contribute towards the necessary repairs of houses and mills.

The general obligation of neighbours as to party walls and fences dividing their premises is the same as that of tenants in common, if they are tenants in common of the wall or fence. One may be, by prescription or contract, bound to repair a fence so as to prevent cattle in his land from straying into his neighbour's.

Subjects of Dilapidations

The subjects of dilapidations are houses and other artificial erections and ways, gardens, land, and trees. Things made by art demand the exercise of art to preserve them from decay. It is only as to such things that the law of permissive waste is applicable. With respect to gardens, lands, and trees, tenants are by the general law merely prohibited from committing voluntary waste. But where lands are let for the purpose of cultivation, as they are almost universally to tenants for years, they are bound to cultivate them in a husbandlike manner, and according to the custom of the country; that is, in the manner in which farm-lands are usually cultivated in the part of the country in which the lands leased are situate.

Gardens.

It is voluntary waste in gardens to cut down the fruit trees, or destroy or remove the shrubs and plants growing there, except for the purpose of cultivation.

Lands.

It is voluntary waste in land to alter its nature so as to diminish its value or affect the evidence of title; an alteration in the course of good husbandry, which does not either diminish the value of the land, or impair the evidence of title, is not waste. It is also waste to take the substance of the land, as clay or minerals, except where open

mines or quarries are leased, in which case there is an implied authority to continue working them.

Waste as to trees consists in felling timber trees, that is, trees which contain, or when mature will contain, wood useful for building purposes. The property in such trees belongs to the owner of the inheritance, and in the case of ecclesiastical property to the Church. No particular tenant can do any act to destroy or injure their growth, or fell them, except for the benefit of the inheritance, as to repair buildings and fences standing on the land demised. It is not waste to cut down trees not timber, in such a manner that they will grow again, unless they have been planted for some particular purpose implying permanence, such as for the ornament or shelter of a house, or for the support of a bank or hedge, or in a field for the shade of cattle. But it is waste to grub up or destroy any trees, whether timber or not. Timber.

There is an important exception to the law against voluntary waste in the instance of fixtures. By this exception a particular tenant, who has made erections or fixed machinery to premises for the purposes of a manufacture or trade, or has added to a house any particular article of ornament or domestic convenience, which may be removed without injuring the house, is entitled to remove the things so fixed. From the occasion and purpose of the annexation, an authority from the owner of the inheritance to fix and remove is inferred, and an intention of the particular tenant to abandon his property in the fixture, which would in ordinary cases be presumed, is negatived. Fixtures.

A nuisance is an act or neglect of a man on his own land, the consequences of which extend beyond his possessions, and encroach upon the possessions or rights of his neighbour. The general law as to the limits of possessions is, that he to whom the soil belongs has a right to all the space perpendicularly above and below; and therefore, so long as the effects of an act or neglect are confined within those limits, there is, generally speaking, no nuisance. But if, in using our land, we encroach upon or disturb our neighbour in the enjoyment of any part of the space above or below his land, such act is a nuisance; as if we build so as to overhang our neighbour's land, and cause the water from the eaves of our building to fall upon his Nuisances to Neighbour's Land;

land, or if we carry on a noisome and offensive trade, so as to corrupt the air over the adjoining land with noxious effluvia, or disturb it with deafening noises, or dig under the foundation of a house standing thereon.

It would manifestly interfere with the conveniences of society, if every noise, or every smell, which the delicate perceptions of a neighbour considered disagreeable, amounted to a nuisance; the law, therefore, modifies itself to the exigencies of mankind, and determines that the noise or stench must be so considerable in degree, and so long continued, as to destroy the comfort of a person of ordinary sensibility in the occupation of his property.

To Easement

Our neighbour may by grant, or by long enjoyment, which causes a grant to be presumed, acquire an easement over our land, for the more convenient or profitable occupation of his own, by which his rights spread themselves into our possessions, and become, as it were, interfused with ours, and operate to control us in the use of our land; in such case it is a nuisance to obstruct his enjoyment of such easement, though we do not encroach upon his territory: thus, if we give him permission to build upon the verge of his land, and to open windows looking over our land, he acquires right to our land for the support of his house, and to the air over our land for light to his house, which rights are called easements; and we cannot dig into our land so as to weaken the foundation of his house, or build so as to darken his windows, though, if he had acquired no right to those easements, either by grant or prescription, we might.

Public Nuisance.

If the tenement be used so as to prejudice the whole neighbourhood, or to injure a public right of way, it is a public nuisance; and the parties causing it are punishable by indictment, at the suit of the Queen, and not by action at the suit of an individual, unless he has sustained some particular injury over and above that inconvenience which he has suffered in common with the rest of the public.

SECT. II.—*Dilapidations by Tenants for Life and Years.*

Parties liable for Waste; Tenant by the curtesy, &c.

By the common law, only tenant in dower, tenant by the curtesy, and guardian, were punishable for waste, because their estates being created by the law, the law annexed to them the condition that they should neither do

nor permit waste; but a tenant for life or for years, whose estate was created by act of the party, was not liable for waste, (that is, for permissive waste,) unless the grantor so stipulated; the parties being at liberty to contract as to the manner in which the tenements should be used: the law did not imply a condition against waste in cases where they did not so provide. This was remedied by the statute of Marlbridge, which provides "that farmers during their terms shall not make waste or exile of houses, woods, or men, or of any thing belonging to the tenements that they have to farm, without special license had by writing of covenant, making mention that they may do it, which thing if they do and thereof be convict, they shall yield full damage, and be punished by amerciament grievously." The statute of Glocester further enacts, "that a man from henceforth shall have a writ of waste in the Chancery against him that holdeth by law of England or otherwise for term of life or for term of years, or a woman in dower; and he who shall be attainted of waste shall lose the thing that he hath wasted, and moreover shall recompense thrice so much as the waste shall be taxed at."

Statute of Marlbridge.

Of Glocester

These statutes extend to every description of tenant for life or years, whether created by grant or devise, to a party to whom lands are granted for an uncertain period to a tenant from year to year, for a year, or half a year. Although a tenant in tail after possibility of issue extinct is not punishable for waste, yet if he grant over his estate, his assignee is but tenant for life, and liable therefore. Every person in whom the estate for life or years becomes vested as assignee, executor, or occupant of an estate per auter vie, takes it subject to the condition against waste.

Tenant for Life and Years.

A guardian in soccage is liable for waste, voluntary or permissive, but not for waste done by a stranger.

Guardian in Soccage.

Tenants at will (that is, those who hold merely at the will of the lessor, and whose estate may be determined at any time, not those who hold under yearly tenancies determinable by notice, and who are sometimes improperly termed tenants at will,) are not included in the statute of Marlbridge or Glocester, and are not bound to do any repairs; but still they cannot lawfully commit voluntary waste.

Tenant at Will.

The estate of tenant at will is so infirm, that it is

reasonable that he should not be bound to do any repairs, since, if he expend money upon the tenements, his lessor may immediately determine his interest, and prevent him from deriving any advantage from such outlay; and if the tenements are falling into decay, it is always in the power of the lessor to enter and take measures for their preservation.

Liability of Tenants for permissive Waste.

Waste is of two sorts, voluntary and permissive. According to the old cases, every tenant for life or years within the statute of Glocester is liable for waste in the same degree; but in modern times doubts have been entertained, though it would seem without any sufficient foundation, whether a tenant from year to year, or a tenant for years, not under covenant, is liable for permissive waste. No distinction can in reason be made between a tenant for life and a tenant for a year, or for a part of year. Each is a farmer within the statute of Marlbridge and a tenant within the statute of Glocester, and each is made liable by the same words; and there is no provision that one shall be liable for one sort of waste and one for another.

Waste in Houses and Buildings.

The statute of Marlbridge prohibits waste or exile of houses, woods, or men, or any thing belonging to the tenements had to farm. These words are large enough to include every thing that is part of the tenements demised. The books enumerate buildings, gardens, lands, and woods, as the subjects of waste. It is proposed to state the law applicable to each of these subjects separately.

First, Voluntary.

And first, of waste in houses and buildings. It has been expressly decided that the law of waste extends not only to dwelling-houses, but to every description of building, such as outhouses and barns, The word houses in the statute includes every description of building: but an incomplete building, such as a pale, a post, or an uncovered wall (which probably means erections not forming part of a building or a fence), are not subject to the law of waste.

Voluntary waste is a wilful act committed by the tenant or by his orders, by which the tenements are destroyed, injured, or altered: it is voluntary waste in a house to prostrate it, or to destroy or remove any part of it, as a post, a door, a window, a furnace, a bench, or

wainscot fixed to the house. The rule against voluntary waste extends to additions made to the house by the tenant himself: thus it has been decided that "glass annexed to the windows by nails or in any other manner by the lessor or the lessee cannot be removed by the lessee, for without glass it is no perfect house. Peradventure great part of the costs of the house consists of glass, which if it be open to tempests and rain, waste and putrefaction of the timber would follow. Wainscot also is parcel of the house, and it makes no difference whether fixed by great nails or little nails, or by screws or irons put through posts or walls (as have been invented of late time); for if wainscot is by any of the said ways, or by any other, fastened to the posts or walls of the house the lessee cannot remove it."

Things merely placed by the tenant on the premises, but not fixed, however bulky such things may be, are not within the rule as to voluntary waste: thus a barn placed upon pattens and blocks of timber lying upon the ground, but not fixed in or to the ground, may be removed; so if it rest upon blocks of stone which are fixed in the ground, but not fastened to the blocks by mortar or otherwise. A mill removable at pleasure, which was an octagonal wooden building, raised on a casement of brickwork and anchored to the ground by shores and land-ties, part of the shores and the whole of the land ties being one foot under the surface of the earth, was found by the jury not to be a fixture. So distillers' vats supported upon brickwork, but not fastened to the ground, are goods and chattels, and no part of the premises on which they are placed. And where certain caps and steps of timber were fixed by a tenant to a building, and he placed in these caps and steps, jibs which he fastened there by pins above and below, the jibs might be taken out of the caps or steps without injuring either them or the building; the jibs were held to be the personal property of the tenant, and no part of the building, so that he did not lose his right to them by leaving them there after the expiration of his term.

Exception to the rule against voluntary Waste.

The right to remove fixtures is an exception to the rule against voluntary waste. By this exception a tenant for life or years, who during his tenancy has fixed certain chattels to the premises for the purposes of his trade or as matters of ornament or furniture, and which can be re-

Fixtures.

moved without injury to the premises, is entitled to remove them, and is not guilty of waste in so doing. Although the cases of tenant for life and of tenant for years are separately treated of in the books on this subject, there is no authority for saying that they are not equally entitled to fixtures. And, as they are made liable for waste without distinction by the statutes of Marlbridge and Glocester, it may be inferred that the exception extends in the same degree to both.

There is distinction between chattels which are substantially of the same character before they are fixed, when fixed, and after removal, such as engines, pumps, and grates, which are engines, pumps, and grates, whether chattels or fixtures; and things the character of which is altered by their annexation to the land, such as buildings which, when fixed, exist as buildings, and before and after severance exist merely as materials, bricks and mortar. Things of the first class may be removed, whether fixed for the purpose of trade or of ornament, or domestic convenience. Buildings, it seems, may be removed if erected for the purpose of trade, but agricultural buildings are not within the same rule as trade buildings.

The law as to farm buildings has been recently modified by the act of the 14th & 15th Vic., c. 25, s. 3, whereby it is enacted "That if any tenant of a Farm or Lands shall "after the passing of this Act, with the Consent in "Writing of the Landlord for the Time being, at his own "Cost and Expense, erect any Farm-building, either de-"tached or otherwise, or put up any other Building, "Engine, or Machinery, either for Agricultural Purposes "or for the Purposes of Trade and Agriculture, (which "shall not have been erected or put up in pursuance of "some Obligation in that Behalf,) then all such Buildings, "Engines, and Machinery, shall be the Property of the "Tenant, and shall be removable by him, notwithstanding "the same may consist of separate Buildings, or that the "same or any Part thereof may be built in or perma-"nently fixed to the Soil, so as the Tenant making any "such Removal do not in anywise injure the Land or "Buildings belonging to the Landlord, or otherwise do "put the same in like Plight and Condition, or as good "Plight and Condition, as the same were in before the "Erection of any thing so removed: Provided, neverthe-

Tenant may remove Buildings and Fixtures erected by him on Farms, unless Landlord elect to take to them.

"less, that no Tenant shall, under the Provision last "aforesaid, be entitled to remove any such Matter or "Thing as aforesaid without first giving to the Landlord "or his Agent One Month's previous Notice in Writing "of his Intention so to do; and thereupon it shall be law- "ful for the Landlord, or his Agent on his Authority, to "elect to purchase the Matters and Things so proposed to "be removed, or any of them, and the Right to remove "the same shall thereby cease, and the same shall belong "to the Landlord; and the Value thereof shall be ascer- "tained and determined by Two Referees, One to be "chosen by each Party, or by an Umpire to be named by "such Referees, and shall be paid or allowed in account "by the Landlord who shall have so elected to purchase "the same.

Things coming within the building class which are annexed for the purpose of ornament or convenience, it may be concluded, cannot be removed, such as an out-house.

Nursery-man's Fixtures.

The right of nurserymen to remove green-houses and hot-houses as trade buildings is left in doubt, it being affirmed by Lord Kenyon, and doubted, if not denied, by Lord Ellenborough. On the one hand, it may be said, that their case resembles those relating to mining fixtures. It is at least a mixed case between occupying land and carrying on a trade. If any distinction can be made, it is in favour of the gardener, green-houses and hot-houses being erected for rearing of exotics, which are raised by the gardener's skill, and have not necessarily any connection with the land demised. On the other hand, it must be borne in mind that the mining cases were not cases of simple buildings, but of machinery and of buildings merely necessary to the machinery, and that green-houses and hot-houses have a peculiar adaption to the nursery ground demised; and it may be presumed were intended to form part of the freehold, unless otherwise agreed.

In consequence of the exception as to fixtures, they have become a peculiar description of property, and there are many rules of law relating to them as such, which are not within the scope of this treatise. It should be noted, however, that the tenant must remove them during his term, and that if he omit to do so, they become the property of the landlord.

Alterations.

An alteration of the buildings demised is wilful waste

if it be injurious to the inheritance, either by diminishing the value of the estate, increasing the burden upon it, or impairing the evidence of title.

There are conflicting authorities as to whether it is waste to build a new house where none was before. The conflict is as to the application of the rule of law, not as to the rule itself. It is not waste simply to alter, but it is waste to alter to the injury of the inheritance. Some think that to build a new house is necessarily a benefit to the lessor, others that it is not. The latter seems to be the better and prevailing opinion. A new house may increase the burdens of the lessor by the charge of its repair; and the act of building a house may be used as evidence that the builder is the absolute owner of the land.

Although a landlord may complain of a new erection as voluntary waste, he may waive this right, and insist upon the tenant keeping it in repair. But if the lessor, without the consent of the lessee, build a cottage on the premises during the lease, the lessee is not liable for waste, either voluntary or permissive, to such cottage.

Improvements.

If a tenant for life or years choose to alter or improve tenements by erecting buildings, or rebuilding, or doing extensive repairs to those already erected, whereby their value is increased, he has no claim at law or in equity against the remainderman or landlord for the value of the improvements.

Permissive Waste in Buildings.

Permissive waste in buildings is the injury happening to them during the term by the permission or neglect of the tenant; that is, an injury which the tenant might have prevented, by taking care of the building, and doing precautionary repairs.

The obligation to preserve the tenements from waste compels the tenant to keep the walls and timbers of the house from exposure, and renders him liable for any injury the fabric or skeleton of the house sustains for want of such repairs as were necessary to preserve it from exposure.

Roof.

The tenant is bound to keep the external coverings, the roof, and other outworks, of the building in repair, and to renew them when they decay, so as to preserve the timbers, walls, and skeleton from premature decay. His obligation to do such repairs is not absolute, but relative, with reference to the condition of the main timbers and walls of the house in consequence of his neglect to do

them. Thus, suffering houses to be uncovered, whereby the spars, rafters, planchers, or other timbers become rotten, is waste; but barely suffering them to be uncovered without rotting the timber is not waste. Where a tenant permitted the standings before the door of his house to be uncovered and out of repair, whereby the principal timbers became decayed and in danger of falling, it was held to be waste.

Glass. Glass is an external covering which the tenant is bound to keep entire; and if in consequence of the windows being broken, the interior of the house is injured, he is liable for waste.

Outer Doors. Outer doors must for the same reason be kept in repair and entire.

Internal Coverings. Plastering. It is also permissive waste if the fabric of the house is injured by reason of the tenant not keeping in repair the internal coverings of the walls.

In Drains, and not Cleansing. He is also bound to keep filth and water out of the house by repairing the groundsills and drains.

Tenantable Repairs. The repairs which a tenant for life or years is bound to do are usually called tenantable repairs. They extend only to the finishing, and not to any part of the skeleton of the house; they include the work of the joiner, plasterer, and glazier, but not that of the bricklayer and carpenter. Stopping out wind and weather, as mending tiles and chimneys, are included in tenantable repairs, because such repairs tend to preserve the fabric of the house from premature decay. They are, therefore, intermediate between substantial and ornamental repairs; bricklayers' and carpenters' work being, generally speaking, substantial repairs; and painting, papering, and whitewashing, ornamental repairs.

Condition of the House when leased. If the house is ruinous at the time of the lease, that is, if the timbers and walls are decayed so that it falls by reason of its age and bad condition, and not by the default of the lessee, it is not waste. If the timbers are standing, but the rafters are gone, and it falls during the lease, the tenant is not liable, because he cannot cover the house without rafters, and he is not bound to find them. On the point whether if a house is simply uncovered at the time of the lease, the tenant is bound to cover it, so as to be responsible for any dilapidations that may ensue by reason of the want of covering, the authorities are conflicting.

Waste by Fire.

Waste by fire, when the fire was caused by the negligence of the tenant, and perhaps when the fire happened accidentally and without negligence, was accounted permissive waste under the statutes; and, according to a recent decision, waste by fire, occasioned by negligence, is permissive waste, but the law on this point is not in a satisfactory state.

Waste by Strangers.

If a tenant suffer a stranger to do waste, he shall be answerable; for it is presumed in law that the tenant may withstand it, *et qui non obstat quod obstare potest, facere videtur.* Another reason given for making the tenant liable for waste done by a stranger is, that he has a remedy against the stranger.

By Under-Tenant.

Being liable for waste by a stranger, of course the tenant is liable for waste by his under-lessee, to whom he has given the opportunity of committing such waste; and a guardian is liable for waste, by those with whom he is connected by privity of estate, as where an abbot was guardian, and one of his monks committed waste; and where joint tenants are guardians, and one of them does waste, both are liable.

Inevitable Accidents.

For dilapidations occurring by inevitable accident a tenant is not answerable, as where a house is destroyed by the king's enemies, who are not amenable to the law, or by superhuman agency, as by lightning or tempest. And where a house has been blown down by tempest, it is not waste for the lessee to sell the materials, because they have become chattels. But if a part of the house which the tenant is bound to repair is destroyed or injured by tempest, he is bound to restore it; as if a house is uncovered by tempest, but the timber is left standing, and it afterwards fall for want of covering, the tenant is liable for waste: and if a tempest take away a small part of the thatch, the tenant is bound to repair it; and if he neglect to do so, and in consequence the house is thrown down by tempest, he is liable for waste.

Where lands are flooded in consequence of the decay of a wall of the sea, or the banks of rivers, it is waste in the tenant; but if the lands be damaged by the sudden rage and violence of the sea, or by a sudden flood of the river, it is not waste; and it has been held, that if the banks of the Trent be unrepaired, it is waste, because the Trent is

not so violent, but that the lessee, by his policy and industry, may well enough preserve the banks.

Covenant to repair; Alterations.

A covenant to repair is negative as well as positive in its obligation; and the tenant is thereby bound as well not to do an act amounting to voluntary waste as to repair dilapidations. Thus an alteration of the demised premises is a breach of a covenant to repair: for example, breaking a doorway through the house demised into the adjoining house. So the act of pulling down a brick wall, which divided one part of the demised premises from another, was held to be a breach of a covenant to repair and uphold the brick walls belonging to the demised premises.

But where the covenant was, that the tenant should leave the premises in as good plight as he found them, and he pulled down houses, the lessor it was held could have no action until the end of the term, for the covenant had relation thereunto; but that if he had wasted the woods, covenant would have lien, because it would be impossible to repair such waste.

And if from the language of the lease it appears that the parties contemplated alterations being made, an alteration is no breach of the covenant to repair. Thus, where the covenant was to repair the demised premises, together with such buildings, improvements, and additions, as at any time during the term should be erected, set up, or made by the tenant, it was decided that the tenant had not broken the covenant by converting the windows on the ground floor into shop windows, and stopping up an internal door in one place, and opening one in another.

Wear and Tear.

A covenant to repair obliges the lessee at all events to repair and restore those parts of the building which fall away, wear out, or are destroyed during the term. He is not bound to repair parts which are merely in progress of decay. His covenant is to repair all accidents, and to take all reasonable precautions against the fabric of the building being exposed to the weather, or becoming more depreciated than it necessarily would from time and ordinary use.

The covenant must be construed with reference to the age and general condition of the building at the commencement of the term. The covenant to repair is not a covenant to improve, or to keep and yield up the building demised in as perfect a state as when demised, but to keep it, as nearly as possible, in the same state as when demised,

and to do such repairs as are adapted to the nature of the building.

The obligation imposed by the covenant to repair differs from the common law obligation against permissive waste in this. The common law obligation is merely to guard the fabric of the building from decay, and is not infringed by an external dilapidation unless the fabric is injured in consequence. By the covenant the tenant is unconditionally bound to repair all dilapidations, whether the fabric of the building is injured or not. Injuries to the building caused by inevitable accident are excepted from the common law obligation, but not from the obligation of a general covenant.

The obligation of a covenant differs from the obligation of an ecclesiastic in this. The ecclesiastic is bound to repair buildings and parts of buildings about to fall away *(proximo casuras)*—those parts which are nearly but not quite worn out. The covenantor is only bound to repair those parts which are actually fallen away and worn out.

Obligation to rebuild when House falls from Decay.

If the house falls merely from natural decay, and without default of the tenant, it would seem that he is not bound to rebuild it under an ordinary covenant to repair.

Painting.

Under a general covenant to repair, the tenant is bound to keep in repair the inside painting, and this, although he expressly covenants to paint the outside.

Materials.

Where any part has fallen away, the tenant is not bound to replace it with new materials, but only with materials of the same value and in the same condition as those deficient ought to have been, had they only been subject to ordinary decay and wear, except from accident or exposure to the weather. In determining this, reference must be had to the age of the building at the time of the lease granted, and to the duration of the lease; and so much ought to be deducted from the cost of new materials as it may be supposed they would be depreciated in value by ordinary wear during the period the materials to be supplied have formed part of the building. Mr. Woods thinks, that in hardly any case could the landlord require more than three-fourths of the new value, and none would occur in which one-fourth ought not fairly to be demanded.

Accidents.

On a covenant to repair, the covenantor is bound to repair at all events, and is not excused from repairing defects caused by inevitable accident. An inevitable acci-

dent does not render it impossible to perform the covenant. The covenant is performed by repairing the consequences of the accident. Where the law infers from circumstances such obligation as is reasonable, there it limits the obligation with those qualifications and exceptions, which under the circumstances are reasonable. It presumes that contract to have been entered into which is just and equal to both parties. But where the parties have themselves expressed the contract which they conceive to be just, there all the law has to do is to apply it to their acts and enforce its performance; for although it may, with much probability, be conjectured that a certain contingency was not foreseen, yet it might have been foreseen, and nothing said about it, because not intended to be excepted from the generality of the obligation. For these reasons, where there is a general covenant to repair, and the buildings are destroyed by accidental fire, the lessee is bound to rebuild. It is no answer to a covenant to repair a bridge, that it was destroyed by an extrordinary flood, such as the covenantor could not resist, and without default on his part. But when a house is destroyed by inevitable accident, the lessee performs his covenant to repair if he rebuild it within a reasonable time; the covenant to repair not meaning that the house shall never be out of repair, but that the lessee will restore all dilapidations which happen during the term.

Independence of Covenants to repair and insure.

The general obligation of the covenant to repair is not limited by a covenant to insure in a specific sum. If such sum be insufficient to rebuild the premises, he must supply the deficiency.

Excuse from Performance by Act of Lessor.

If the dilapidations are caused by the act or neglect of the landlord himself, or if he renders it impossible for the tenant to perform the covenant, the breach of covenant is excused.

But an act of the lessor which merely impedes but does not wholly prevent the lessee from performing his covenant, cannot be alleged by him as an excuse for a breach.

And so it is no answer to an action on a covenant for not repairing and cultivating, that the plaintiff entered on parcel of the demised premises, and ejected the defendant therefrom.

By License of Lessor.

And a covenant cannot be discharged by a parol license of the covenantee. If the landlord, by word of mouth, or

writing (not being a deed), authorize the lessee to do an act which is a breach of covenant, the lessee is liable to an action of covenant notwithstanding.

Independence of Covenants to repair and to pay Rent.

And the tenant is not excused from the performance of a covenant to pay rent by the premises becoming untenantable by inevitable accident, as if the house demised is burned down, or land is surrounded by water, or the tenant is evicted by a foreign enemy. And where the lease contains covenants to pay rent and to repair, and in the covenant to repair the case of the premises being destroyed by fire is excepted, the tenant must pay the rent accruing after the premises have been destroyed by fire, and before they are rebuilt; and he must do so although it be assumed that it is the duty of the lessor to rebuild, the covenants being distinct, and he having a sufficient remedy by action against the lessor for not rebuilding. It has since been decided that such an exception does not bind the landlord to rebuild.

Obligation to pay Rent when Premises are burned.

Obligation to pay Rent when Premises untenantable in Tenancies without Covenant.

And when premises demised by verbal or written agreement, from year to year, or for a shorter time, are destroyed by fire, in which case the tenant is not bound to rebuild, the destruction of the building does not determine the tenancy, and the tenant still continues liable for the rent.

It is now settled, notwithstanding some decisions to the contrary, that the tenant has no right to quit the premises because they are at the commencement of the tenancy untenantable from dilapidations, which ought to have been repaired by the landlord, or become so during its continuance, unless such power is expressly reserved, and except, perhaps, in the case of a furnished house, or furnished apartments, which are taken merely for the purpose of temporary occupation. It is not a condition implied on the demise of real property, that it shall be fit for the purpose for which it is demised, or shall continue fit for such purpose. In this respect the modern and the ancient authorities agree.

Covenant to improve.

Sometimes leases contain covenants to alter and improve: where they do, such covenants must be strictly performed, and they are not satisfied by substantial and thorough repairs.

Again, a covenant to make a shop front is not performed by merely enlarging windows, though such enlargement be sufficient for the purposes of the tenant's trade; and in

matters of taste, as to the style and manner in which a house is covenanted to be rebuilt, equity will enforce a specific performance; for instance, a covenant to make the elevation of a house correspond with the elevation of the adjoining houses.

Another covenant relating to dilapidations is the covenant to insure. The object of this covenant is to compel the tenant to procure a Joint Stock Insurance Company to become responsible for the repair of dilapidations by fire. Covenant to insure.

The covenant to insure binds the tenant to effect an insurance directly the covenant is made.

The insurance must be regularly continued without intermission, and must be strictly according to the covenant.

By the Building Act of 14 Geo. III., Insurance Offices are required, on the request of any persons interested in houses or buildings destroyed or damaged by fire, to lay out the insurance money in rebuilding or repairing the premises. The Act is confined to London and Westminster, and the Bills of Mortality.

In ejectment on the ground that the lease has been forfeited by not insuring, it lies upon the landlord to prove that the premises were not insured. The tenant refusing the landlord information as to insurance, or refusing to show a policy upon demand, is no evidence of non-insurance. In an action on the covenant it seems that the tenant would have to prove performance.

In an action for breach of this covenant the damages are not necessarily nominal. Where the landlord has effected an insurance on the tenant's default, though such act is not the necessary consequence of such default, and therefore the landlord is not as a matter of law entitled to recover the premiums paid, the jury may, if they please, award the amount of such premiums, by way of damages, as a sum reasonably expended to relieve himself from the anxiety incident to the premises being uninsured. But where the landlord was a leaseholder under a covenant to insure, and he demised to the tenant under a similar covenant, the tenant failed to insure, and the superior landlord brought ejectment, and recovered, it was held by the Court of Common Pleas that the sub-landlord was only entitled to nominal damages in an action against his tenant for breach of his covenant. He was not entitled to the value of his estate in the premises, because that had been forfeited by

the breach of his own covenant, and not by the breach of the tenant's.

Extent of Covenants to repair.

Besides the degree of care which the covenant to repair imposes, there are three other points to be attended to in the construction of such covenants:

As to Things.

On the first point, a general covenant to keep and leave in repair the premises demised will extend to every part thereof, and every thing attached thereto, which can be considered as part of the freehold, and not removable by the lessee as a tenant's fixture.

The tenant is bound to leave a building erected by himself in substantial repair, although the erection was originally of defective construction.

Extension to Persons.

On the second point, all covenants relating to the manner of using the premises during the term, as to repair houses, to cultivate lands, run with the land, and are binding not only on the lessee, but also on the assignee of his interest, though he be not expressly named. And such covenants affect all and each part of the land demised; and therefore, if the lessee assign his interest in part of the land, the assignee is bound by the covenants to repair and to cultivate, so far as they are applicable to the part of the land which he holds. And they may be taken advantage of, as well by the assignee of the reversion as by the lessor himself. And the assignee of the reversion of part of the premises may sue on a covenant relating to such part.

The assignee of the lessee is liable by the common law to perform the covenant. The right of the assignee of the reversion to enforce performance is founded on the stat. 32 Hen. VIII., c. 4, which only applies where the lease is by indenture; and therefore when a house is let by verbal or written agreement, and the tenant agrees to repair, and the landlord assigns his interest, the assignee cannot sue the tenant for not repairing; and as there is an express agreement to repair with the original landlord, an agreement with the assignee to use the premises in a tenant-like manner cannot be implied. The original landlord, of course, may sue on the agreement, notwithstanding the assignment of his reversion. But in such case, if the tenancy is merely from year to year, and the tenant or his assignee continue as tenant from year to year of the lessor or his assignee, an agreement between the new parties will

be implied that such renewed tenancy shall be on the old terms.

Notwithstanding some decisions to the contrary, it is now decided that an assignee in equity of a lease, for instance, a party who has had it deposited with him by way of equitable mortgage, is not liable on the covenants as assignee, and that the Court of Chancery will not compel him to take an assignment.

A covenant to do any thing upon the land, as to build a wall or a house, or which in any way affects the land, as in a lease of mines, a covenant to build a smelting mill, is a covenant which runs with the land, and the benefit thereof will pass to the assignee of the reversion. But such a covenant being to do a specific act, and not continually to be performed during the term, does not bind the assignee, if not named. Thus, if B covenant for himself, his executors and administrators, to build a wall, the assignee is not bound, because the intention appears to be that the wall shall be built by the lessee before assignment; but if the covenant be that the lessee or his assigns shall build a wall, the assignee is bound. If the lessee covenant for himself and his assigns to build a house within a certain time, and assign after the expiration of the time, the assignee is not bound; but if he assign before the covenant is broken, the assignee is. The assignee of the reversion cannot sue for a breach of covenant before the conveyance to himself.

A covenant not to build is at all events, in equity, binding on the assignee, and the Court will restrain the assignee, who has notice of such covenant, from violating it.

Duration of Covenant.

In considering the third point, the time during which the obligation of a covenant to repair continues, it is to be seen, first, when it begins; and, secondly, when it ends.

The obligation to repair usually commences at the date of the lease, or at the commencement of the term when the term commences subsequent to the date of the lease. But when the habendum is from a day prior to the date of the lease, the covenant binds from the date of the lease.

A covenant to leave in repair at the end, or other sooner determination of the term, applies when the term is determined by notice, according to a power reserved to the lessee.

When a lease is conditioned, that if the lessee does not repair within six months after notice, the lessor may re-

enter, the notice to repair must be given to the lessee or his assignee. A notice to repair given to an under-lessee will not suffice.

A general covenant to repair is not only obligatory during the continuance of the lease, but also, where the lessee continues tenant after its determination, it will be presumed that he holds under the same terms.

Those covenants alone are implied as continuing in force which regulate the manner in which the tenements shall continue to be used.

Form of Covenant.

There are no particular formalities requisite to give validity to an agreement to repair, as that it should be contained in a valid lease of the premises.

Waste in Gardens.

Waste may be committed in a garden or orchard. Thus it is waste to cut down apple-trees, or pear trees growing in a garden or orchard; but not if they grow scatteringly on divers places of the land. When apple trees are blown down, the tenant may take them; but where such trees were abated by a great wind, and fell upon the crops, and several of the boughs fell into the ground, and the trees bore fruit two years afterwards, it was held waste for the lessee to grub them up.

A gardener who cultivates trees for their fruit has no right to remove them; but a nurseryman who rears them to sell and transplant has a right to remove.

Nor can the tenant of a pleasure garden remove trees, ornamental hedges, or shrubs, or a border of box, although planted by himself, such things being intended to be permanent; nor can he plough up a strawberry-bed before it is exhausted.

There is no authority for saying that a tenant is under any positive obligation to cultivate a garden or orchard; the cases only establish a negative obligation against voluntary waste. The tenant is entitled to cultivate and to remove or transplant any plants in the fair course of cultivation, but not to remove things merely for his own benefit, unless the purpose for which the garden was let authorizes him to do so, as in the case of a nurseryman; nor can he alter the character of the garden, or any part of it, as by ploughing up a strawberry bed and sowing turnips.

Waste in Lands; Alteration.

It is waste permanently to alter the character of land, though its value may be increased, such as to convert

meadow into arable land by ploughing it up, or arable land into wood, or a meadow into an orchard, because it not only changes the course of husbandry, but affects the proof of title. But it seems that if a meadow is ploughed for the purpose of improving it as a meadow, and not of permanently altering its character, as where by the custom of the country it is good husbandry to do so, it is not waste to plough it: and so it seems the tenant may root up bushes, furze, and thorns growing on the land, for melioration: for that is good husbandry, and he is entitled to such things for fuel. The rule appears to be, that a permanent alteration of land, which necessarily affects the evidence of title, or any alterations which diminish the value of the land, is waste; but a mere temporary alteration in the ordinary and reasonable course of husbandry is not: and by reason of the injury to the evidence of title, it is waste to enclose and cultivate waste land.

It is waste if the tenant take away the substance of the land, as if he dig and take away clay, because the soil is impoverished for want of clay; and he cannot open mines, quarries, or clay-pits: but if mines, quarries, or clay-pits are open, and in work, when the estate for life or years is created, the tenant may continue to work them; because an intention that he may do so may be presumed; but it seems that a tenant for life has no right to re-open and work clay-pits which the grantor had ceased to work before the creation of the estate. A tenant has no right to minerals deposited on the land by mountain streams. Mines.

As a tenant is entitled to work mines open at the time the lease is granted, so he may use all means necessary for working them, and therefore may open new shafts and pits to follow the same vein of coal. "Otherwise," said Lord Chancellor King, "working in the same mine would be impracticable, because the miners would be choked for want of air, if new holes were not continually opened to let the air into them; and the same vein of coal frequently runs a great way, and is very knowable, and easy to be discerned.

The Court of Chancery will restrain a tenant for life or years from sowing woad or mustard, they being poisonous and exhausting plants, by which the vegetative power of the land is destroyed.

A tenant is bound to keep the fences in repair, and he Fences.

may cut timber for this purpose; but he has no right to make fences where none were before. And it would appear that he is not liable if the fences become dilapidated from natural decay, and there is no wood on the premises with which he can repair them.

Obligation to cultivate Lands.

By the general law a tenant for life or for years is under no obligation to cultivate lands. Thus it is not waste to suffer arable land to lie fresh and not manured, so that it grows full of thorns; it is merely ill-husbandry. To oblige a tenant to farm according to good husbandry, there must either be an express contract or a custom of the country. In most, if not all cases in which lands have been usually let to farmers, there is a custom of the country regulating the manner in which the lands are to be cultivated.

A custom of the country need not have existed from time immemorial, as must a custom properly so called. It is the approved habits of good husbandry practised in that part of the country in which the lands are situate, and is a means of ascertaining the course of cultivation adapted to the nature of the lands. It may be proved by covenants usually inserted in farming leases, and need not be definite and precise.

The obligation to expend manure, and right to remove must in every case, where there is no express contract, be governed by the custom of the country. There is no rule of law on the subject, irrespective of such custom: farmers are more fit than lawyers to decide such a question.

The obligation to cultivate lands according to the custom of the country does not apply to a garden or to a meadow let with a gentleman's residence.

Where there is a special agreement as to the manner in which the lands shall be cultivated, the obligation to cultivate according to the custom of the country is superseded, as where the tenant agreed to farm the land in a good and husbandlike manner, to be kept constantly in grass; and where the landlord recovers damages for the conversion of a meadow into arable land, he cannot also recover for removing the straw grown on such land, as contrary to the custom of the country as to the cultivation of arable land.

Obligation as to Live Stock, Doves, &c.

If tenant of a park, vivary, warren, or dove-house, destroy so many of the deer, game, rabbits, or doves, that sufficient be not left for store, having regard to the num-

ber at the time his estate was created, it is waste. To stop the holes of a pigeon-house so as to prevent the pigeons building there, is waste. If the tenant of a park permit the pales to decay, so that the deer escape, he is liable for waste. Breaking a wear or suffering the banks of a fish-pond to decay, so that the water and fish run out, are respectively acts of waste. But the subversion of coney-burrows has been held not to be waste.

Emblements are the products of the earth, which a tenant, the determination of whose estate is sudden and fortuitous, is allowed to take after his interest in the land has expired, in consideration of his labour and manurance employed upon the land: "lest the ground should be unmanured, which would be hurtful to the commonwealth, he shall reap the crop which he sowed in peace." The doctrine of Emblements has been entirely changed by the act of the 14 and 15 Vic., c. 25, sec. 1, whereby it is enacted: Emblements.

On determination of Leases or Tenancies under Tenant for Life, &c., instead of Emblements Tenant to hold until Expiration of current Year, &c.

" That where the Lease or Tenancy of any farm or " Lands held by a Tenant at Rackrent shall determine by " the Death or Cesser of the Estate of any Landlord en- " titled for his Life, or for any other uncertain Interest, " instead of claims to Emblements, the Tenant shall con- " tinue to hold and occupy such Farm or Lands until the " Expiration of the then current Year of his Tenancy, " and shall then quit, upon the Terms of his Lease or " Holding, in the same Manner as if such Lease or " Tenancy were then determined by Effluxion of Time or " other lawful Means during the Continuance of his " Landlord's Estate; and the succeeding Landlord or " Owner shall be entitled to recover and receive of the " Tenant, in the same manner as his Predecessor or " such Tenant's Lessor could have done if he had been " living or had continued the Landlord or Lessor, a fair " Proportion of the Rent for the Period which may have " elapsed from the Day of the Death or Cesser of the " Estate of such Predecessor or Lessor to the Time of the " Tenant so quitting, and the succeeding Landlord or " Owner and the Tenant respectively shall, as between " themselves and as against each other, be entitled to all " the Benefits and Advantages, and be subject to the " Terms, Conditions, and Restrictions, to which the pre- " ceding Landlord or Lessor and such Tenant respectively

" would have been entitled and subject in case the Lease " or Tenancy had determined in manner aforesaid at the " Expiration of such current Year: Provided always, " that no notice to quit shall be necessary or required by " or from either Party to determine any such Holding and " Occupation as aforesaid."

Waste as to Timber.

Timber trees are parcel of the inheritance, and a tenant for life or years has only a right to their shade and fruit during the term. It is waste if he cuts them down, or does any act to cause them to decay, as if he lops or tops them. Timber trees are such as are useful for the purpose of building. Oaks, ashes, and elms are timber in all places. Thorn-trees, which have stood for sixty or a hundred years, have been accounted timber. In some countries where timber is scant, beeches and white-thorns are used for building, and therefore accounted timber: in such case it is waste to fell or injure them. In the Countess of Cumberland's case, birches of a hundred years' growth, which were serviceable for timber, for sheep-houses, cottages, and other mean buildings, were held to be timber, which a tenant for life had no right to cut. If by custom oaks and ashes are seasonable wood, and cut at stated times, the tenant may cut them at such times; thus, if it is customary to cut ashes every ten years, the tenant may cut them.

It is also waste to cut down any trees, though not timber, such as beeches, maples, willows, &c., which are planted for the defence or ornament of the house, or in a pasture-field for the shade of cattle, or on a bank to sustain it, or which form part of a hedge, it being the apparent intention of the landlord or grantor of the estate that such trees shall continue.

It is not waste to cut down trees which are not timber, either by law or custom, and are not planted for any of the above special purposes, in such a manner that they will grow again. Thus a tenant for years may lawfully cut down willows, leaving the stools or butts from which they will shoot afresh. Whitethorns, blackthorns, and hazels may in like manner be cut down.

Nor is it waste to cut the underwood of hazels, willows, or thorns, maple or oak. But if the tenant dig up such trees, or underwood, or suffer the germins to be bitten by cattle after they are felled, so that they will not grow

again, or mow the stocks with a wood scythe, it is waste. Against such waste the Court of Chancery will grant an injunction. It is not waste for the tenant to fell timber trees which are completely dead, and bear neither fruit nor leaves, and have not sufficient timber in them for buildings or posts.

If timber trees are blown down by tempest, or severed from the land by other means, they become the property of the tenant who takes the first estate of inheritance. But if dotards, or old trees which have no timber in them, are blown down, they become the property of the tenant. And if the landlord fells such trees during the term, the tenant may take them.

As the tenant is entitled to cut hedges and bushes, the cuttings belong to him; and if a stranger cut them, the landlord cannot maintain an action. The trimmings of fir trees under twenty years old belong to the tenant for life, and not to the remainderman.

The tenant being entitled, during his term, to the shade and fruit of timber trees, if the landlord fell them, he may maintain trespass.

An equitable tenant for life has no right to cut timber without the consent of the trustees; if he does, he is bound to account for the timber and its proceeds to the trustees.

Felling decayed Timber.

When timber is in a state of decay, and will not improve by standing, but is likely to do damage to other trees, and when the felling of it will be a benefit to all parties concerned, the Court of Chancery will order it to be cut down, either on the application of the tenant for life or of the remainderman. When the application is by the remainderman, care will be taken that the tenant for life is not prejudiced by those trees being taken which are necessary for repairs. The Court will not order generally that those trees be cut down which are fit to be cut, and which a provident owner might think fit for felling. Timber will on like conditions be ordered to be cut when the tenant entitled to it is an infant.

When trees are thus felled by order of the Court of Chancery, the produce of the sale is invested, and the tenant for life has the interest for his life, such being equivalent to the fruit and shade of the trees. The first person entitled to cut timber is entitled to the capital in-

vested. Thus, when lands are conveyed in trust for A., for life remainder to B., for life without impeachment for waste, the proceeds arising from the sale of timber belong to B., on the death of A.

Ornamental timber and trees planted for the defence and safety of the house will not be allowed to be cut down, though decaying.

Right to cut Timber for Repairs, &c.

A tenant for life or years may cut timber for the repairs of his house, barns, or fences, for the necessary purposes of husbandry, or to be consumed as firewood. He may fell timber to repair houses which he is not strictly bound to repair; for instance, those which were ruinous at the time of the lease, or those which the lessor covenants to repair, because the law favours the supportation of houses of habitation for mankind. But he cannot take timber for improvements, such as to make fences where none existed before; or to repair houses which he has wasted, or suffered to be wasted, nor can he cut timber for the purposes of working mines, such being no benefit to the land. The right to cut timber for firewood is qualified, and the lessee can only justify cutting timber trees for that purpose when there is no underwood or deadwood upon the land.

Timber can only be cut down for the express purpose of being used in the repairs of buildings, &c. It cannot lawfully be sold to raise money for the purchase of other timber; nor can it be exchanged for other timber better adapted for the repairs in question. If the timber be cut down bonâ fide for the purpose of being used in reparations, the tenant is justified, though he may have over-calculated the quantity required; but he cannot cut down timber by way of anticipation, to be used in dilapidations which may happen at some future time.

Where, by the lease, the lessor is to assign trees to the lessee for requisite repairs, and a particular tree is assigned to the lessee by the lessor's bailiff, such assignment operates as a delivery, and vests the property of the tree in the lessee, who may fell at any time afterwards.

Covenant as to Trees.

Where the tenant covenants to deliver up all the trees standing in an orchard at the time of the demise, reasonable use and wear only excepted, he is not precluded from removing trees decayed and past bearing from a part of the orchard which is too crowded. Where there is a cove-

nant not to remove or grub up trees, the tenant cannot remove trees from one part of the premises to another, unless they are dead, even although he plant more trees than he removes.

Where Trees are excepted out of Lease.

Sometimes trees are excepted out of the lease; they are then considered as in the possession of the lessor, and are not subject to dilapidations or waste; but if the tenant cut or fell them, the landlord may have an action of trespass against him. Where trees generally are excepted out of a lease, such exception is construed to relate to timber trees only, and not to apple or other fruit trees, or the like; since, if it did, the tenant would not be entitled to the fruit of such trees. And where the exception was of timber and other trees, but not the annual fruit thereof, it was held that apple-trees were not within it, because it was to be construed strictly against the lessor.

SECT. III.—*Dilapidations by Mortgagee or Mortgagor.*

Obligation on Mortgagee to repair.

A mortgagee, who in equity is considered as holding the land as a pledge for the payment of his debt, is bound to preserve the premises from extraordinary dilapidations; but for that depreciation which is caused by gradual decay, the mortgagee is not responsible.

Right to alter or rebuild.

Although, generally speaking, a mortgagee has no right to alter the mortgaged tenements, yet he may pull down ruinous houses, and build better ones, to prevent a forfeiture.

Reimbursement of Expense.

He is entitled to be allowed for repairs necessary for the support of the property, and for the expenses of doing that which is essential to the maintenance of the mortgagee's title. But he will not be allowed monies expended in increasing the value of the property, unless the mortgagor has consented or acquiesced. If he has improved the property with the consent of the mortgagor, he is entitled to be reimbursed the monies expended, with interest, in the same manner as if it was a new loan.

Right of Mortgagee to Timber and Minerals.

The mortgagee in possession has no right to cut down timber, except the land is an insufficient security, when it seems that the mortgagee may sell the timber. He cannot open and work mines, or take brick earth; if he does, he is chargeable with the gross receipts, and not allowed any of the expenses.

Right of Mortgagor to Timber.

The mortgagor cannot cut down timber to the prejudice of the security; and therefore if it appear that the security is scanty, equity will restrain him from felling timber, but not unless it be clearly shown that the security is deficient, the presumption being that it is not. If he have cut down timber to the prejudice of the security, and sold it, he will be ordered to pay the amount into Court, in trust for the mortgagee. Underwood, which is in the nature of a crop, the mortgagor will not be restrained from cutting at seasonable times, and this though the underwood be expressly mentioned in the mortgage. But where the mortgagor becomes bankrupt, his assignees will be enjoined from taking even underwood, because the mortgagee is entitled to the land in exactly the same plight as it is at the date of the bankruptcy, and to prove for the residue of his debt.

Sect. IV.—*Dilapidations of Party Walls and Fences.*

Property in Party Walls.

Where a party wall exists between two buildings or gardens, which is used by the occupiers of both buildings indiscriminately, and it does not appear on whose land it was built, the presumption is that the parties are tenants in common of the wall. The presumption of property arising from acts of ownership must correspond with those acts; and, as in the case of a party wall, each party equally makes use of the whole wall, the inference is that they are equally entitled to the whole wall. It follows that if one party build against the wall on his side, no action can be maintained by the other. And if one pull down the wall for the purpose of rebuilding it, or heighten it, it is not a trespass against his neighbour; but the neighbour may have an action on the case for the temporary loss of the protection of the wall, or for any injury he may sustain from the increased height, or he may pull down any additional erection upon the wall. And one tenant in common of a hedge may have trespass against his co-tenant if he grub it up, but not if he merely clip it. Whether a party wall standing between two houses belong half to the owner of one house and half to the other, or is the common property of both owners, one has no right to underpin any part of the wall, unless he can do it without injury to the house of the other.

The rebuilding and repairs of party walls within London

and a limited district around, are regulated by the Metropolitan Buildings Act, by which the owner of one of the houses separated by the party wall may, under the superintendence of a district surveyor and official referees, rebuild or repair the party wall when necessary, either with or without the consent of the owner of the other house, and recover contribution from other parties benefited by the works. As this statute is of itself a book, and there have been as yet no legal decisions on its provisions, this general reference to it must suffice.

In the case of a party wall out of the limits of the Building Act, the rights and liabilities of parties with respect to the repairing or rebuilding it will be the same as those of tenants in common, if they are tenants in common of the party wall. If half the wall belongs to each party, then each may repair or rebuild his part.

Property in Fences.

In the case of a fence between two fields, which has a ditch at its base, the presumption is that the fence belongs to the party on whose side the ditch is not. It is reasonable to suppose that, in making the fence by the party who made it, the ditch was dug on the verge of his own land, and the earth thrown up on his land, so as to form a bank on which to plant the fence. And thus, the outer edge or side of the ditch furthest from the hedge is presumed to be the boundary of the lands; and if the party to whom the fence belongs proceeds to widen the ditch, it is *prima facie* a trespass on the neighbour's land. Where there are ditches on both sides the hedge, or where there is no ditch at all, the proprietorship of the hedge may be proved by acts of ownership; and if both parties have equally exercised acts of ownership, the right of property will, I apprehend, be presumed to be common.

Obligation to repair Fences

A tenancy in common in a party wall or fence does not imply any obligation in one tenant towards his companion to repair such wall or fence, nor does the existence of a fence on a man's land impose on him any obligation to repair it as against his neighbour.

Who bound to repair.

Though the obligation to repair a fence be annexed to the fee simple of the land, yet the party bound to do the repairs is the actual occupier, he being the person whose immediate duty it is to prevent cattle from straying from one close into the other; and having the exclusive possession of the fence, he is the only person who can lawfully

repair it, or who can be presumed to know of the defects.

Who to complain of Dilapidations.

The obligation to repair is only towards the occupier of the adjoining close, and not general, as against the public; and therefore a party seeking to take advantage of that obligation, either as excusing a trespass, or charging the obligor for injuries happening to his cattle, must show an interest in the adjoining close, or a right to have his cattle there.

Sect. V.—*Dilapidations of Highways and Bridges.*

Obligation of Inhabitants of Parish.

By the general rule of the common law, the parish—that is, the occupiers of land within the parish—are bound to repair all the highways therein. Sometimes, by special prescription, the inhabitants of a township are bound to repair highways within the township, and sometimes one parish is bound to repair highways situate in another. A corporation or individual may be bound to repair highways by reason of the tenure of some particular lands; an individual may also be bound to repair highways by reason of enclosure. These are exceptions: the general rule is, that parishioners shall repair the highways; and where the parties bound by prescription become insolvent and unable to repair, the charge falls upon the parish. Where the inhabitants of a township had immemorially repaired highways within the township, and a new road was made by Act of Parliament, which expressly exempted the inhabitants of the township from the charge of repairing it, it was held, that, *ex necessitate*, the rest of the parish were liable. And where a turnpike road is made by an Act of Parliament, and placed under the management of trustees, who are to repair out of the tolls, the parish may be indicted if the road be out of repair, because they are liable by the general rule of the common law; and the tolls, &c., in the hands of the trustees, are only an auxiliary fund; and if such fund fail, recourse can only be had to the parish. But where such road is made in a township which, by prescription, is bound to repair the roads within it, the inhabitants of the township must repair, because, by the prescription, the township stands in the place of a parish as to the repair of highways. It is obvious that the parishioners cannot discharge themselves from their liability

to repair a highway by agreement or otherwise, since such an agreement would affect the rights and security of the public, to whom the parish is bound. Where highways are situate within an extra-parochial hamlet, it has been doubted whether the inhabitants of such hamlet are, without a special custom, liable to repair; but it would seem, upon principle, that they are liable to repair, because otherwise the roads would not be repaired at all; and in the case of a turnpike road, there could be no persons ultimately liable to keep it in repair, in the event of the tolls, &c., proving inadequate, because to such road no prescription or custom would apply.

What is a Highway.

Every thoroughfare which is used by the public is a highway, whether it be a carriage-way, a horse-way, or a foot-way: a navigable river is a highway. In one case parishioners were indicted for not repairing stairs leading to the Thames. A way merely leading to a church, a village, or a private house, and therefore not useful to the public generally, is not a highway.

A highway may be created by Act of Parliament; and when it has been recognized in an Act of Parliament as public, it is a highway, and repairable as such. Where a highway is created by a temporary Act, it ceases to be such when the Act expires, and statute duty done upon it in obedience to the Act is no adoption of it by the public. When, by Act of Parliament, trustees are empowered to make a road or roads, no part of them becomes a highway until the whole are made. But when several roads are authorized to be made, and it is provided that they shall not become public until two justices have certified that the said roads respectively are fit to be travelled on, each road becomes public so soon as the justices have certified; and it is not a condition that they shall all be made before any are public highways.

Dedication of Highway.

Formerly, wherever a party made a way over his land, and dedicated it to the public, and the public used the way, it became a public highway, and repairable by the parish. Now, by the Highway Act, (which came into operation on the 30th of March, 1836,) "No road or occupation-way made, or hereafter to be made, by and at the expense of any individual or private person, body politic or corporate, nor any roads already set out, or to be hereafter set out, as a private driftway or horse-path, in any award of Com-

missioners under an Enclosure Act, shall be deemed or taken to be a highway, which the inhabitants of any parish shall be liable to repair, unless the person proposing to dedicate such highway to the use of the public shall give three calendar months' previous notice, in writing, to the surveyor of the parish, of his intention to dedicate such highway to the use of the public, describing its situation and extent, and shall have made, and shall make, the same in a substantial manner, and of the width required by the Act, and to the satisfaction of the surveyor and two justices of the peace, of the division in which such highway is situate, in petty sessions assembled."

Limited Dedication.

A way may be dedicated for a limited time; it may also be dedicated for particular periods, as where it appeared that a bridge was used by the public at all times, on foot and with horses, but only occasionally with carriages, in times of flood and frost, when it was unsafe to pass through the river. In ordinary times the carriages went through the ford, and the bridge was sometimes barred against carriages by a chain, locked to posts. Lord Ellenborough held that this was a public right of way, limited as to time. It has been doubted, however, whether there can be a partial dedication of a way, that is, of a right of way for some carriages and not for others. The argument against such a dedication is, that it is unjust for the public generally to be obliged to repair a road which a portion of the public only are allowed to use.

There cannot be a dedication to a particular part of the public, as to the inhabitants of a parish; such a dedication is simply void.

Where lands chargeable with the repair of a highway are conveyed to several, they are all liable to do the repairs in proportion to the quantity of land they hold; though if the way be dilapidated, any one of the proprietors may be indicted separately, and compelled to pay the whole fine. He may proceed against those who are jointly liable with him for contribution. If lands so chargeable come into the hands of the Crown, they are not discharged.

It is the occupier and not the freeholder of the lands chargeable with repairs of a highway against whom the indictment should be preferred. But the occupier is entitled to be reimbursed by his landlord the sum expended in repairs.

Width.

The surveyor is to make every cart-way leading to any market-town twenty feet wide at the least, every horse-way eight feet wide, and every foot-way at the side of any cart-way, &c., three feet wide, if the space between the fences will admit thereof.

Width of Gateways.

Gateways across any carriage-way must be ten feet wide, and across any horse-way five feet wide, clear between the posts; and if the owner of any narrower gate omit to enlarge or remove it after twenty-one days' notice from the surveyor, he is liable to a penalty not exceeding 10*s.* per day for so long time as he so neglects.

Removal of Snow.

The surveyor is bound to remove any accumulation of snow within twenty-four hours after notice from a justice of the peace. He is empowered to make, scour, cleanse, and keep open all ditches, gutters, drains, or water-courses, and to make and lay such trunks, tunnels, plats, and bridges, as he may deem necessary, in and through any lands, adjoining the highway, making the owner or occupier compensation if the lands are not waste or common; the amount to be settled in the same manner as the amount of damages for getting materials from enclosed lands.

Cleansing Ditches, &c.

If any person alter or obstruct the ditches, &c., after they have been taken under the charge of the surveyor, he is bound to reimburse the surveyor the expense of reinstating them, and to forfeit a sum not exceeding three times such expense.

Direction-Posts, &c.

The surveyors of parishes more than three miles from the post office are also required, with the consent of the vestry, or by the direction of the justices at special sessions, to set up direction-posts or stones in places where two ways meet, and boundary stones; and on such parts of highways as are subject to floods, to erect graduated stones to guide travellers the safest track through the floods, and to secure horse causeways and foot causeways from being passed over by waggons, by banks of earth, posts, and stones.

Encroachments.

No tree, bush, or shrub can be planted on any carriage-way within fifteen feet of the centre. And if the owner do not remove it within twenty-one days after notice from the surveyor, he forfeits 10*s.* for every neglect.

Centre of Highway.

The highway is that portion of ground which has been maintained and repaired by the surveyor for six months next preceding, and the fifteen feet are to be measured from the centre of that.

If the surveyor think that a highway is prejudiced by any hedges or trees (except trees planted for the ornament or shelter of any hop-ground, house, building, or court-yard,) he may summon the owner of the land before a justice, who may determine whether the trees, &c., shall be cut, pruned, or plashed. If the owner fail to obey the order of the justice, the surveyor may cut the hedge, and the owner must reimburse him the expense incurred.

Cutting Hedges.

No person can be ordered to cut any hedges between the last day of September and the last day of March, nor to fell any timber tree, unless the highway is ordered to be widened, and then he can only be compelled to grub up oak-trees in April, May, and June, and ash, elm, or other trees in December, January, February, and March.

Materials for Repairs of Highways.

The surveyor may, with the consent of the vestry, contract for the purchase of materials required for the repair of highways. He is not to have any interest in such contract without the license of two justices at special sessions, under a penalty not exceeding £10, and incapacity of being employed as a surveyor with a salary.

Where lands belonging to parishes, or to the surveyor of highways for the purpose of obtaining materials, become exhausted, the surveyor may, with the consent of justices at special sessions, sell the land to the owner of adjoining land, or, if he refuse, to any other person, for such price as the justices think reasonable, and apply the money, with like consent, in the purchase of other lands.

The surveyor may search for, dig, and carry away gravel, sand, stone, or other materials, in any waste, common, river, or brook, within the parish; or, if sufficient cannot be obtained in his parish, he may take them from any other parish, leaving sufficient for the repairs of the highways in such parish.

Where sufficient materials cannot be had in the waste, commons, rivers, and brooks, the surveyor may, with the license of two justices at special sessions, dig and carry away materials from the enclosed land of any person within the parish (such land not being a garden, yard, avenue to a house, lawn, park, paddock, or enclosed plantation, or enclosed wood not exceeding one hundred acres), or within any parish adjoining the highway, if sufficient materials cannot be had within the parish or in the wastes, &c., of the adjacent parish, and so that sufficient materials be left

for the repairs of the highway in the parish where the lands lie. These questions to be determined by the justices. The surveyor is to make satisfaction for the materials taken, and also for the damage done to the lands in taking and carrying away the same.

Of Bridges.

Public bridges, if not within a city or town corporate, are repairable by the inhabitants of the county; if within a city or town corporate, by the inhabitants of such city or town. If part in one shire, city, or town, and part in another, the inhabitants of the shire, city, or town, are bound to repair so much of the bridge as lies within their limits. A bridge may, by custom, be repairable by the hundred or parish in which it is situate; or an individual may by prescription be bound to repair, by reason of the tenure of lands.

How repaired.

Those who are bound to repair bridges, must make them of such height and strength as shall be answerable to the course of the water; *and if it take a new channel*, they must erect a bridge there. But they are not bound to widen the bridge, however convenient or necessary it may be to the public.

Causeways to

Counties are also bound to repair the highways at the ends of bridges for 300 feet.

What a public Bridge.

Every bridge which is of public utility is a public bridge, and *prima facie* repairable by the inhabitants of the county. Although the bridge is erected by a private individual for his own private advantage, yet, if it becomes of public benefit, it is a public bridge.

By 43 Geo. III., c. 59, s. 5, no bridge built by an individual shall be deemed a county bridge, unless erected in a substantial and commodious manner, under the direction, and to the satisfaction, of the county surveyor, or person appointed by the justices at quarter sessions, or, in Lancaster, by the justices at the annual sessions; which surveyor, or person appointed, is to attend and superintend the erection of the bridge, when required by the party erecting the same; and if the builder be dissatisfied, the matter is to be determined at the quarter or annual sessions.

The justices of the peace are to appoint two surveyors, with salaries, to see bridges amended.

Sect. VI.—*Nuisances.*

Definition of a Nuisance.

A nuisance may be defined to be a wrongful act or neglect of one man, in the use or management of his land, which occasions damage to the possession or easement of his neighbour, or to a public easement.

Acts injurious to private Possessions.

Any act done by one man on his land which is the cause of an encroachment on that of another, to his damage, is an actionable nuisance.

If, in consequence of an act done in one colliery, damage is caused to another, though at some distance, an action lies by the owner of the colliery injured.

Offensive Trades.

In determining what acts are nuisances, it is necessary to ascertain the legal extent of the possessions of an occupier of land. He to whom the soil belongs is entitled to all the space of air above to the sky, and of the earth below to the centre. His rights extend perpendicularly above and below his own land, and not laterally, so as to claim any use from the earth beneath or the air above the adjoining land. It is therefore not only a nuisance to cause an encroachment or injury to the soil of a neighbour, as if a house is built overhanging the land of another; but also if the air over his land is corrupted or disturbed by noisome smells or deafening noises, it is a nuisance.

Not every disagreeable smell or noise which spreads from one man's land to his neighbour's is actionable. The smell or noise must arise from some permanent cause, and occasion continual annoyance and discomfort, to a degree sufficient to depreciate the value of a dwelling-house, and render it less eligible in consequence of the neighbourhood. A man is not restricted in the fair and reasonable use of his land by any delicacy of sense or peculiarity of habit of his neighbour. A pig-sty, lime-kiln, privy, smith's forge, tobacco mill, tallow furnace, and glass-house, set up near a private residence, are nuisances. And so a mill for steeping sheep-skins, by which the air is corrupted; a building for manufacturing acid spirit of sulphur, which occasions noisome and offensive smells; a place for slaughtering horses. It is not essential that the stench raised should be unwholesome; it is sufficient if it renders the enjoyment of life and property uncomfortable.

Any wilful and mischievous act of one man which disturbs another in the enjoyment of the reasonable profits of his land is a nuisance, though without the malicious motive of the agent the act is innocent. Disturbance of occupation of Lands.

It is also a nuisance to the occupier of the land over which it flows to obstruct or divert a stream of water. By this act a natural profit is prevented from coming to the land. "The proprietor of land on each bank of a stream is *prima facie* entitled to half the land covered by the stream, but there is no property in the water. Every proprietor has an equal right to use the water which flows in the stream, and, consequently, no proprietor can have the right to use the water to the prejudice of any other proprietor. No proprietor can either diminish the supply of water, which would otherwise descend to the proprietor below, or throw it back upon the proprietor above." By grant, or by prescription, a proprietor may acquire a right to take the water, to the prejudice of the other proprietors of land on the banks of the stream; but by merely appropriating to himself water which is not at the time useful to the other proprietors, he acquires no such right. Thus, a person who first builds a mill on the banks of a stream has no right to pen back or divert the water for the supply of his mill, so as to diminish the quantity of water which would come to the proprietors below, on the ground that they have not applied the stream to any particular use. Diversion of Water.

In public navigable rivers no right can be gained, even by prescription, to divert or obstruct the stream, to the prejudice of the public. All that the proprietor of the land on the banks (and to whom the soil belongs, to the middle of the river) can do, is to take so much water as may be necessary for his private purposes by pipes, or otherwise, so as not sensibly to diminish the quantity, to the prejudice of the navigation.

Where the ancient course of water is to flood certain lands at certain seasons, the owners of those lands cannot justify fencing it off their lands, to the prejudice of other property; though, if such be not the ancient course of the waters, they may. Thus if a river periodically inundates the surrounding country at certain places, the parties whose lands are thus periodically subject to floods have no right to protect their lands against the river, if they thereby cause the waters to flood the lands of their neighbours, Protection of Lands from Inundation.

because by such act they improve and increase the value of their property at the expense of their neighbours.

Nuisances to Foundations.

A man who builds a house on the verge of his own land, has no right to the support of his neighbour's land for the foundation of his house; nor if he build against the wall of his neighbour's house, has he any right to the support of such wall; and if he place windows looking towards his neighbour's land, he cannot complain if his neighbour build so as to obstruct the light.

If the occupier of a house suffers it to be dilapidated so as to injure the adjoining house, he is liable to an action. If one has conduit pipes passing by the foundations of the house, and he neglects to repair them, whereby the house is injured, it is a nuisance.

So a party having a water course in his land is bound to cleanse it, at all events so as to prevent its becoming injurious to his neighbour; and is liable for an obstruction, although he has no notice of it.

The cases as to nuisances caused by fire have already been stated.

Easements.

An easement is a right which one man has to use the land of his neighbour for a special purpose.

By Prescription.

A prescriptive right to the easement of light is acquired by twenty years uninterrupted enjoyment, unless it appears that such enjoyment was had by some consent or agreement expressly given for that purpose by deed or writing. The enjoyment must be by a window or opening in a building, by which the claimant visibly appropriates the light flowing through such window to himself.

Dangerous Nuisance.

If a person suffers his tenement to become dangerous to the public, or exercises an occupation dangerous to health or life in a public situation, he is guilty of a nuisance. Thus, if the occupier of a house near a highway suffer it to become so dilapidated that it is likely to fall on the passengers, he is indictable.

Remedies for Nuisances: Abatement.

A private nuisance may be abated by the party injured by it, provided he commits no riot in the abatement; but a public nuisance cannot be abated by an individual, unless he is specially inconvenienced thereby.

CHAPTER XXII.

THE LAW RELATING TO APPRAISERS AND AUCTIONEERS.

SECT. I.—*The Law relating to Appraisements.*

None but duly qualified persons can act as Attorneys.

BY the Laws regulating Attorneys, no person who is not admitted and enrolled, and otherwise duly qualified to act as Attorney or Solicitor, can sue out any writ or process, or commence, carry on, or solicit any action, suit, or other proceeding, in any Court of Equity, or Law, Civil or Criminal. (6 & 7 Vic., c. 73, s. 2.)

Under penalty of £50.

By 44 Geo. 3, c. 98, s. 14, Every person, who, for, or in expectation of fee, gain, or reward, draws or prepares any Conveyance or Deed relating to any real or personal estate, or any proceedings in Law or in Equity, other than and except a Serjeant-at-Law, Barrister, Solicitor, Attorney, Notary, or Proctor, having obtained a regular certificate; Special Pleader, Draftsman in Equity, or Conveyancer, being a Member of one of the four Inns of Court, and having taken out a certificate; or a person employed to engross any Deed, Instrument, or other proceeding, not drawn or engrossed by himself, as a public officer preparing a public document, in the course of his duty, is liable to a penalty of £50. The act does not extend to prevent any person from preparing a will, an agreement not under seal, or a letter of attorney.

Appraiser must obtain License.

By 46, Geo. 3, c. 46, Appraisers are required to obtain licenses from the Inland Revenue Office, for the purpose of carrying on their business; and appraisements are required to be stamped.

Definition of an Appraiser.

Every person who values or appraises any estate or property, real or personal, or any interest in possession or reversion, or any goods, merchandise, or effects, for, or in expectation of hire, fee, gain, or reward, is an Appraiser within the act. (s. 4.)

No person can act as

No person can exercise the calling or occupation of an

Appraiser without License.

Appraiser without taking out a license, which is granted by the Commissioners of Inland Revenue. (s. 5.)

Licenses, when dated.

Licenses issued between 5th July and 5th August, are dated 6th July; those issued at other times are dated on the day of issue. Every license continues in force until the 5th of July following its issue.

Penalty of £50 for acting as Appraiser without License.

Any person who appraises or values any estate or property, &c. for, or in expectation of hire or reward, without being licensed, is liable to a penalty of £50. (s. 6.)

An Auctioneer can act as Appraiser.

An Auctioneer duly licensed as such, may act as an Appraiser without an Appraiser's license. (s. 7.)

Appraiser must deliver Valuation within fourteen days on stamped paper.

Every Appraiser must set down in words or figures every valuation made by him, and the full amount thereof, and within fourteen days deliver the same, duly stamped, to his employer, under a penalty of £50. (s. 8.)

Employer who receives an unstamped Valuation liable to Penalty.

If the employer of an Appraiser receives, or pays, or makes compensation for making an appraisement, and the same is not set down on paper duly stamped, he forfeits £20. (s. 9.)

One Sheet of Paper only need be stamped.

If more than one sheet or piece of paper is used in writing an appraisement, that only which contains the aggregate amount of the valuation need be stamped. (s. 10.)

License subject to £2 Stamp.

The license to use and exercise the calling or occupation of an Appraiser in the United Kingdom, is (by 8 & 9 Vic., c. 76,) subject to a stamp duty of £2.

License to be taken out yearly.

It must be taken out yearly by every person (except a licensed auctioneer) who exercises the calling or occupation of an appraiser, or who for, or in expectation, of any gain, fee, or reward, makes any appraisement or valuation chargeable by law with any stamp duty.

Amount of Stamp Duty on Appraisements.

The stamp duty on Appraisements is imposed by 55 Geo. 3, c. 184, on an Appraisement or valuation of any estate or effects, real or personal, heritable or moveable, or of any interest therein, or of the annual value thereof, or of any dilapidations, or of any repairs wanted, or of the materials and labour used, or to be used in any buildings, or of any artificer's work whatsoever.

Where the amount of such appraisement			£.	s.	d.
or valuation exceeds not	.	£50 .	0	2	6
Where it exceeds £50, and exceeds not		100 .	0	5	0
„ 100	„	200 .	0	10	0
„ 200	„	500 .	0	15	0
„ 500		.	1	0	0

Exemptions.

The exemptions from duty are

Appraisements or valuations made in pursuance of the order of any Court of Admiralty or Vice-Admiralty, or of any Court of Appeal, from any sentence, adjudication, or judgment of any Court of Admiralty or Vice-Admiralty.

Appraisements or valuations of any property made for the purpose of ascertaining the legacy duty payable in respect thereof.

Penalties, how recoverable.

It should be noted that the above penalties can only be sued for in the name of the Attorney-General, or of the Solicitor of Stamps, or some other officer of the Stamps. (44. Geo. 3, c. 98.)

Unlicensed Appraiser cannot recover his Charges.

If a person acts as an Appraiser without being licensed, or if an Appraiser omits to write his appraisement on a stamp, his conduct is illegal, and he cannot recover for his services. (Palk *v.* Force, 17, Law Jour., G. B. 299, 12 par. 797.)

Stamp Acts do not apply to Valuations made for private information only.

The Stamp Acts do not apply to appraisements made merely for private information, but to such only as are intended to be binding between two parties with opposing interests. Thus, a valuation of parish lands made by a farmer and a basket-maker for the sidesmen of the parish, with a view to the equalisation of the poor-rate, has been held not to require an appraisement stamp, and the farmer and basket-maker recovered compensation for their services, although they were not licensed as Appraisers. (Atkinson *v.* Fell, 5 Maule & Sel. 240.) And so, where two partners in a coal mine directed a third person to balance the profit and loss of the concern, and to value the materials and utensils, and each party was to take an article alternately at his valuation, until the whole was divided, it was held that the valuation so made was for the mutual information of the partners; and although it was afterwards adopted as the terms of their agreement, it was not an appraisement within the stamp laws. (Jackson *v.* Stophurd, 4 Tyr. 330.)

Appraisement does not require Award Stamp.

An appraisement or valuation although it is agreed to be and is binding upon the parties as an award, does not require an award stamp. Thus a valuation of the amount due to a builder for building a house was held to be sufficiently stamped with an appraisement stamp. (Perkins *v.* Potts, 2 Chit. 399.) So an appraisement of the amount to be paid by an incoming to an outgoing tenant for stock

and implements, and of the amount to be allowed by the outgoing tenant for repairs, is sufficiently stamped with an appraisement stamp. (Leas *v.* Burroughs, 12 East. 1.)

Sect. II.—*The Law of Auction.*

£10 Stamp on Auctioneer's License.

By 8 & 9 Vic., c. 15. The Auction Duty is repealed, and an Excise Duty of £10 is imposed upon every License to be taken out annually by every person exercising or carrying on the trade of an Auctioneer, in any part of the United Kingdom.

Every Auctioneer is required to take out License.

Every person who exercises or carries on the trade or business of an Auctioneer, or who acts in such capacity at any sale or roup, and every person who sells, or offers for sale, any goods or chattels, lands, tenements, or hereditaments, or any interest therein, at any sale, or roup, when any person or persons become the purchaser of the same, by competition, and being the highest bidder, either by being the single bidder, or increasing upon the biddings made by others, or decreasing on sums named by the Auctioneer, or person acting as Auctioneer, or other person, at such sale, by any other mode of sale, by competition, is required to take out the license. The license should be renewed annually, ten days at least, before the expiration thereof, on the 5th day of July, in each year. Every Auctioneer having had such license, who continues to carry on the business of an Auctioneer in the year next ensuing the expiration thereof, and omits to renew his license as aforesaid, and every person who carries on the business of an Auctioneer as aforesaid, without taking out such license, forfeits £100.

Which must be renewed annually.

Auctioneer conducting business without License, forfeits £100.

Persons exempt from License.

Persons selling goods or chattels by auction under a distress, for non-payment of rent or tithes, to a less amount than £20, or under the authority of any act or acts of parliament, in force on 8th May, 1845, in which an exemption is given to the officer of a court to sell effects seized under the process of the court, by auction, without taking out or having any license as an Auctioneer, if the sum for which the process is enforced, is under £20, need not be licensed as Auctioneers.

Auctioneer can sell any kind of goods.

A licensed Auctioneer may sell any description of goods without having an excise license to authorise him to sell such goods by retail; and may sell by auction gold and

silver plate, patent medicines, and other articles, without a special license for the sale of such things.

Must post his Name in Sale Room.

The Auctioneer before beginning the auction must affix or suspend, or cause to be affixed or suspended, a ticket or board containing his true and full christian and surname, and residence, painted, printed, or written in large letters, publicly visible or legible in some conspicuous part of the room or place where the auction is held, so that all persons may easily read the same, and must keep such ticket or board so affixed or suspended during the whole time of such auction being held, under a penalty of £20.

Must show his License on demand, or deposit £10.

The Auctioneer must at the time of any sale by auction on demand of any officer of excise, customs, stamps, or taxes, produce and show to such officer a proper license granted under the act and then in force, or deposit with the officer £10. If he fails, he may be arrested and detained by any officer of the peace. Any officer of the peace, at the request of the excise officer, &c., may at the termination of the sale, or sooner, if convenient, arrest and convey the person acting as Auctioneer, before a Justice of the Peace, of the county, or place, where the sale has been held, and the Justice may examine into the fact or facts charged, and upon proof either by confession of the party offending, or by the oath of one or more credible witness or witnesses, (which oath the Justice is empowered to administer), that the person brought before him did act as an Auctioneer as aforesaid, and did not produce such license, or deposit such sum of money, may by warrant made under his hand commit the offender to the common goal or house of correction, for the county or place where the sale has been held, for any time not exceeding one calendar month from the day of the commitment. Neither the imprisonment nor the deposit prejudices or affects any proceedings afterwards instituted for the recovery of the penalty incurred for acting as an Auctioneer, without the license by the act directed. If the Auctioneer deposits the £10, and before the expiration of a week from the date of the sale produces to the officer a proper license to him granted and in force before and at such sale, the officer must immediately repay the deposit; otherwise, he must, at the expiration of the week, account for it to the Commissioners of Inland Revenue, or such persons as they may appoint to receive it.

Each Partner must be Licensed.

If persons carry on the business of Auctioneers in partnership, each partner must take out a separate license. (6 Geo 4, c. 81, s. 7.)

Auctioneer's duty to make productive Sale.

With respect to the duty of an Auctioneer, he should, before the sale, take all proper and usual precautions by advertising, &c., to make the sale as productive as possible to his client.

Conditions of Sale, Auctioneer liable for omissions.

If he takes upon himself to frame the conditions of sale, which, if a solicitor is employed, are usually drawn out by him, he should insert all usual and proper conditions which the subject of sale requires. If, in consequence of his omission to insert proper and usual conditions, the sale proves ineffectual, he is not entitled to recover anything from his employer for his services. Dunew was employed by Daverell to sell a leasehold estate; he omitted to insert in the particulars of sale a condition that the purchaser should not inquire into the lessor's title. The purchaser, as he was entitled to do in the absence of express stipulation to that effect, called for the lessor's title, which Daverell being unable to furnish, could not make out his title. An action having been brought by Dunew for the money which he supposed to be due to him for endeavouring to sell the property, Lord Ellenborough held that he was entitled to recover no compensation for his services because they had been found to be wholly abortive by reason of his own neglect. (Dunew *v.* Daverell, 3 Campb. 451.)

Description of Property must be substantially correct, or the sale is void.

He should describe the property to be sold correctly in the particulars. Any material misdescription will render the sale voidable by the purchaser, as if a house is described to be a free public-house, when the lease contains a covenant binding the tenant to take beer of a particular brewer. (Jones *v.* Edney, 3 Campb., 294.) So if a right of way is omitted or misdescribed in the particulars and plan, (Dykes *v.* Blake, 4 Bing, Q.C., 463,) or if an objectionable projection is omitted, (Pope *v.* Garland, 4 *Y* & *Z.*, 403.) Any extraordinary condition to which the property is subject, should be described. An annuity payable out of the tolls of Waterloo-bridge was put up for sale, but was not described as redeemable, which it was, the purchaser was allowed to repudiate his contract. (Coverley *v.* Burrell, Sugden on Vend., 211.) On a sale of leasehold property, it was omitted to be mentioned that an Act

of Parliament empowered a company to purchase it, the result was the same. So on the sale of a wood, an incorrect description of the average size of the trees prevented the seller from enforcing the contract. (Lord Brooke, v. Rownthwaite, 5 Hare, 298.)

A Condition that misdescription shall not annul Sale, does not apply to fraudulent misstatements.

Even if there is a condition that misdescriptions shall not annul the sale, but that compensation shall be given for the difference in value, it will not apply to a fraudulent misstatement or a misdescription, so far affecting the subject matter of the contract, that it may be reasonably supposed that but for such misdescription the purchaser might never have entered into the contract. (Flight *v.* Booth, 1 Bing, Q. C., 377.) Thus, where before the reform in parliament an estate was described as situate about one mile from Horsham, (a parliamentary borough,) when it was between three and four miles from that place, the error was held fatal. (Duke of Norfolk *v.* Northy, 1 Campb., 337.) And so where a lease at a rack rent was described as held at a ground rent. (Stewart *v.* Alliston, 1 Mer., 26.) So where a house which was built partly of brick and partly of timber—parts of the exterior of which were built of only lath and plaster, and had no party wall, was described as a brick-built dwelling-house. (Powell *v.* Double, Sugden 21.) So where the particulars described a house as No. 4 instead of No. 2, although the name of the occupier was correctly stated, and the houses No. 2 and 4 were of the same description, and the latter was rather in better repair than the former, the purchaser was not bound. (Leach *v.* Mullett, 3 C. & P., 115.) So where a house was held under a lease, and a small yard, which was an essential part thereof, was held under a yearly tenancy, and the particulars omitted to notice the difference of tenure. (Dobell *v.* Hutchinson, 3 Ad. & E., 355.)

If Timber, or Fixtures, are to be taken at Valuation, the Particulars must so state it.

If the purchaser is to take timber or fixtures at a valuation it should be so expressed in the particulars or conditions; if not, he will be entitled to them as part of his purchase without additional payment. (Higginson *v.* Clowes, 15 Ves. junr., 516; Colegrave *v.* Dias Santos, 2 P. & C., 76.)

Misdescription of Goods bought by inspection, is not fatal.

In the case of goods, which the purchaser sees at the time of bidding for them, and buys from inspection, a misdescription is not fatal to the contract, but it may in some cases be considered as amounting to a warranty that the

goods are of the description specified; if they are not, the auctioneer may be liable to an action for breach of warranty.

Auctioneer not liable for mistakes arising out of mere matter of opinion.

But if from the nature of the subject of sale the description can only be fairly considered as matter of opinion, a mistake there being no fraud, does not render the auctioneer liable. Thus, on a sale of pictures by auction, one was described in the catalogue as by Claude Loraine, and another by Teniers, Lord Kenyon held that the description was a mere statement of the seller's opinion, and not binding. (Lendwine *v.* Slade, 2 Esp. 572.) A different decision was arrived at by a jury, where some pictures were described in an invoice as the work of Canaletti. The court refused to disturb the verdict, remarking that he was a very old painter, (he died in 1798,) and that it was for the jury to say, under all the circumstances, whether the words in the invoice implied a warranty of genuineness, or conveyed only a description or an expression of opinion. Littledale, J., observed, that all the auctioneers in London would be alarmed if they thought that words such as those used were to be understood as a warranty. (Power *v.* Barham, 4 A. & R., 470.)

Puffing at Sales.

It is illegal to employ puffers, or even one person to screw up the price, unless the fact is publicly advertised and known. Such conduct is a fraud upon the bidders, and inconsistent with the usual condition that the highest bidder shall be purchaser; but it seems to be the better opinion that one bidder may be employed to prevent the property from being sold at an under-value. (Sugden on Vendors, 8.)

Statute of Frauds extends to Sales by Auction.

As the Statute of Frauds, 29 Car. 2, c. 3, extends to sales by auction, it is necessary for the auctioneer to attend to its provisions.

Contract of Sale, or Agreement, must be in Writing.

The 4th section enacts "That no action shall be brought whereby to charge any person upon any contract or sale of any lands, tenements, or hereditaments, or any interest in or concerning them, unless the agreement upon which such action shall be brought, or some memorandum or note thereof shall be in writing, and signed by the party to be charged therewith, or some other person thereunto by him lawfully authorised."

What circumstances binding.

The 17th section is, "That no contract for the sale of any goods, wares, or merchandize for the price of £10 ster-

ling, or upwards, shall be allowed to be good, except the buyer shall accept part of the goods so sold, and actually receive the same, or give something in earnest to bind the bargain, or in part of payment, or that some note or memorandum of the said bargain be made and signed by the parties to be charged by such contract, or their agents, thereunto lawfully authorised."

Sale of Lands.

On a sale of lands by auction, there must be a writing signed by the party to be charged, specifying the names of the vendor and purchaser, and all the particulars and conditions of the contract.

Sale of Goods.

On a sale of goods of the price of £10 or upwards, there must either be such a writing, or a part payment, or earnest, or acceptance of the goods, or part of them.

Auctioneer is generally Agent of both parties.

The auctioneer is in most cases considered to be agent of both parties to sign the contract. His employment by the vendor to sell gives him authority to sign for him, and the purchaser by bidding confers on him an authority to sign for him, unless he otherwise expresses himself. (Kenworthy *v.* Schofield, 2 B. & R., 945; Bartlett *v.* Parnell, 4 A. & R., 792.) So that if he signs a sufficient memorandum in writing, either party may enforce the contract against the other. But the signature of the auctioneer will not make him to sue the purchaser on the contract, because if he appears as principal he is not allowed to say that he was the agent of the other party. (Farebrother *v.* Simmons, 5 B. & Ald. 333.)

Auctioneer's Clerk Agent for purchaser

The auctioneer's clerk is the agent of the purchaser, to sign the contract, if he signs it in his presence without objection. The auctioneer may sue on a contract so signed. (Bird *v.* Boulter, 4 B. & Ad., 443.)

Sale of each Lot is a separate contract.

On a sale by auction, the sale of each lot is a distinct contract, and therefore in the case of goods, if the price of each lot is under £10, the Statute of Frauds does not apply. And the acceptance of or part payment on one lot does not establish the contract as to the other. (Roots *v.* Lord Dormer, 4 B. & Ad. 77.)

Acceptance of Goods. What amounts to it.

Nice questions sometimes arise as to what amounts to an acceptance of goods within the statute. Some ear-rings were put up to auction upon a condition that the purchaser should pay a deposit of 30 per cent. Bristolli was the highest bidder, at 88 guineas; the ear-rings were thereupon handed to him, and he received them without

objection; after they had been in his hands three or four minutes he returned them to the auctioneer, saying, that he had been mistaken as to the price at which they had been knocked down. The auctioneer refused to receive them: he did not pay the deposit. Lord Tenterden at the trial ruled, that there had been an acceptance. The court granted a new trial, remarking that it was improbable that the auctioneer intended to part with the property before payment of the deposit, and that there was very slight evidence of acceptance, which was a question for the jury. (Phillips *v.* Bristolli, 2 B. & C., 911.)

Auctioneer holds deposit as a Stakeholder.

If a deposit is paid to the auctioneer, he holds it as a stakeholder between the parties, and is bound to pay to the vendor immediately the contract is completed, or to the purchaser, if the purchase goes off, immediately the vendor has made default. As he may be called upon to pay the deposit at any moment, he is not liable for interest, although he may have invested the money and made interest thereby, (Harrington *v.* Hoggart, 1 B. & Ad., 577,) nor is he liable to any expenses which the purchaser has been put to. But if he has put up the property for sale without authority, he is liable both to interest and expenses. (Noratt *v.* Ellis, Sugden, 30.) He is not entitled to any notice of the purchase being completed or going off, but must inform himself of the circumstances, and pay over to the party entitled at his peril. He impliedly undertakes to do so when he receives the deposit. (Duncan *v.* Cafe, 2 M. & W., 244.)

If vendor fail to perform Contract, Auctioneer must return deposit to the purchaser.

If the vendor is not ready to perform his contract at the stipulated time, the auctioneer is bound at law to return the deposit to the purchaser; and this, although the purchaser is not prepared, and although if the case is within the Statute of Frauds, negotiations and steps towards completion have been taken after the time, unless the time has been enlarged by an agreement, signed by the purchaser or his agent. (Stowell *v.* Robinson, 3 Bing, N. C., 928; Clarke *v.* King, Ry. & Mood, 394.) He may not be so bound if proceedings in equity have been taken by either party. If sued for the deposit, the auctioneer has no right to compel the vendor and purchaser to interplead. He cannot be relieved from the performance of his contract which is to pay the deposit to the party entitled. (Deller *v.* Prickett, 15 Ins., 168.)

An auctioneer being employed to sell and obtain the best price from a third person cannot purchase the property himself. (Esp. Hughes, 6 Ves., 617.)

Auctioneer cannot purchase himself.

As he has an interest in the contract of sale for his commission, he may sue on the contract in his own name. (Williams *v.* Millington, 1 H. Br. 81.)

May sue a Purchaser.

He is also personally liable as principal to the purchaser if he does not disclose the name of his principal. (Hanson *v.* Roberdraw, Peake, 120.)

Is liable if he does not disclose the name of his principal.

If he bona fide sells goods which he has no right to sell, he is not liable to the purchaser, as upon a sale by auction or other sale of goods there is no warranty of the title to the goods sold. (Morley *v.* Attenborough, 3 Ex., 500.) But he is liable to the real owner of the goods.

Is not liable to purchaser for selling Goods he has no right to do, if he acts in good faith.

Although he is employed by the owner of premises to sell on them, he has no right to remain on the premises if the owner revokes his authority and requires him to quit even though his remaining there is necessary to complete his contract with the purchasers of the goods. He must quit the premises directly he is requested by the owner, and if he sustains any damage in consequence, must sue the owner. (Taplin *v.* Florence, 15 Ins., 402.)

As to selling on the premises.

An auctioneer, as well as every other agent, when he has performed the stipulated service, is entitled to the remuneration agreed to be paid him, or if there is no express agreement to the customary remuneration. And if there is an agreement as to the rate of payment, it will be construed with reference to the custom of the business, if such custom be so notorious as to render it probable that the employer knew of it.

Auctioneer entitled to remuneration when service is completed.

It is the custom of auctioneers employed to sell estates to claim their commission upon a sale being completed, although the sale has not been effected by them, and this custom has been considered to be incorporated into agreements with their employers, if not expressly excluded. In Driver *v.* Cholmondeley (9 C. & P., 559) tried before Lord Denman and a special jury, in 1835, the plaintiffs claimed a commission of 1 per cent. on £128,500, the price of an estate which one of the defendants had sold by private contract after the plaintiffs had been employed to sell it under an agreement, by which they were to have 1 per cent. on the purchase-money; the defendants contended that as the plaintiffs had not effected the sale, they were

Entitled to Commission, although the Sale is not effected by him.

not entitled to the commission, but the jury gave them a verdict. In Rainy *v.* Vernon, (9 C. & P., 599,) the plaintiff was employed to sell ground rents by auction, on the terms of receiving a commission of 1 per cent. on sale. After he had advertised the property, the defendants sold it by private contract. Mr. Winstanley proved the custom to be that if an auctioneer is employed, and a sale advertised, and before sale the property is sold by the owner himself, the auctioneer is to be paid his commission. If the particulars are prepared before the employment of the auctioneer it makes no difference. If the auctioneer inserts advertisements and calls the attention of the public to the property, and brings forward a person who eventually becomes the purchaser, he is always paid his commission. Mr. Shuttleworth confirmed Mr. Winstanley. Mr. Hoggart said, the usage is for the auctioneer to receive his commission after he is employed, however the property may be sold. The amount of commission does not depend upon whether the auctioneer does much or little. Lord Denman directed the jury that if they thought that a usage so notorious that the defendants must have known it, had been proved, it was part of the contract. But if the custom was not so notorious, it was not engrafted on the contract, and the fair value of the plaintiff's services only ought to be given. The verdict was for the amount of the commission. (See Maltby *v.* Christie, 1 Esp., 340, and see Lawrence, 3, in Tomkins *v.* White, 3, Smith, 440.)

In Murray *v.* Currie, (7 C. & P., 584,) it was proved to be the custom of land-agents, that where several were employed to sell an estate, the agent who found a purchaser was entitled to a commission of 2 per cent., whether he did anything more towards the completion of the purchase or not. It appeared that the purchaser was first informed that the estate was in the market by the plaintiff, but he negotiated the terms of the purchase through the agent employed by the defendant. Lord Denman left it to the jury to say whether the plaintiff had found the purchaser, in which case he said they were to find for him, otherwise not; but he told them that they were not bound to give him all the commission that he claimed. They found for the plaintiff for part of the commission claimed.

If by agreement, Commission is to be calculated

If by the terms of the agreement, commission is to be paid on the sum obtained, nothing is due until the contract

is completed, and the purchase-money paid to the vendor. (Bull *v.* Price, 7 Bing., 237.) On a negotiation for an exchange of livings the employer agreed to pay the agent his commission when the abstract of the conveyance was drawn out. The court held that he was not entitled to be paid when an abstract of title on one side only had been delivered, no abstract having been delivered by the other party. (Alder *v.* Boyle, 4 C. B., 635.) But if the employer, having the opportunity to complete the contract, wilfully refuses to do so, the agent is entitled to his commission. (Horford *v.* Wilson, 1 Taunt., 12 W. Tindal, C. J.; Bull *v.* Price, 7 Bing., 241.)

on the sum obtained, nothing is due until the Contract is completed, and money paid.

By agreement, an auctioneer was to have a commission of 1 per cent. if the estate was sold by auction, or within two months afterwards, or ½ per cent. if it was not sold within two months. The estate was not sold by auction, but was sold more than two lunar months, but within two calendar months, afterwards. The court held that it was not a mercantile contract, in which the term month always means a calendar month, and that *prima facie* month meant lunar month, but that it was for a jury to say whether there was any usage of trade for month in such cases to mean calendar month. (Simpson *v.* Margisson, 11 Q.B., 23.)

Conditions of Sale—On the Sale of Freehold Property.

1. That the highest bidder shall be the buyer: and if any dispute arise as to the last or best bidder, the lot in dispute shall be put up at a former bidding.

2. That no person shall advance less at any bidding than £ —— or retract his or her bidding.

3. That every purchaser shall immediately pay down a deposit, in the proportion of £—— for every £100, of his or her purchase-money into the hands of the Auctioneer, and sign an agreement for payment of the remainder to the proprietor, on the ——— day of ———— next, at ————, at which time and place the purchases are to be completed, and the respective purchasers are then to have the actual possession of their respective lots; all outgoings to that time being cleared by the vendor.

4. That within ———— from the day of the sale, the vendor shall at his own expense, prepare

and deliver an abstract of his title to each purchaser, or his or her solicitor; and shall deduce a good title to the lots sold, commencing with a deed bearing date the —— day of ————, A.D. ——, and that no earlier title shall be enquired into or required.

5. That if from any cause the purchase shall not be completed at the time mentioned in the 2nd condition, the purchaser shall pay interest on his purchase money at the rate of 5 per cent., per annum, in addition thereto.

6. That the purchaser of each lot shall pay for all tenant's fixtures and timber on his lot, at a valuation to be made by two valuers or their umpire, one valuer to be named by the vendor and one by the purchaser, within —— days after the sale, and if either party shall neglect to appoint a valuer, the valuation shall be made by the valuer appointed by the other, and shall be final. That the amount of such valuation shall be paid at the time and place mentioned in the 2nd condition in addition to the purchase-money, or in default of payment, interest shall be paid thereon according to the 5th condition.

7. That upon payment of the remainder of the purchase-money, the amount of the valuation and interest as aforesaid, the vendor shall convey the lots to the respective purchasers: each purchaser, at his or her own expense, to prepare the conveyance to him or her, and to tender or leave the same at ———— for execution by the vendor.

8. That if any of the purchasers shall neglect or fail to comply with the above conditions, his or her deposit-money shall be actually forfeited to the vendor, who shall be at full liberty to re-sell the lot or lots, bought by him or her, either by public auction or private contract, and the deficiency (if any) occasioned by such second sale, shall immediately after the same sale, be made good to the vendor by the defaulter at this present sale: and in case of the non-payment of the same, the whole thereof shall be recoverable by the vendor, as liquidated damages, and it shall not be necessary to previously tender a conveyance to the purchaser.

Lastly. That if any mistake be made in the description of the premises, or any other error whatever, shall appear in the particulars of the estate, such mistake or error shall not annul the sale, but a compensation or equi-

valent shall be given or taken as the case may require. Such compensation or equivalent to be settled by two referees, or their umpire; each party within ten days after the discovery of the error, and notice thereof given to the other party, to appoint one referee by writing; and in case either party shall neglect to nominate a referee within the time appointed, the referee of the other party alone may make a final decision. If two referees are appointed, they are to nominate an umpire before they enter upon business, and the decision of such referees or umpire (as the case may be) shall be final.

Conditions to be inserted where the title deeds cannot be delivered up.

That as the title deeds which concern this estate relate to other estates of greater value, the vendor shall retain the same in his custody, and enter into the usual covenants (to be prepared by his solicitor and at his expense) for the production of them to the respective purchasers; but all attested copies which may be required of such deeds shall be had and made at the expense of the person requiring the same.

Where an estate is intended to be sold in lots, and the title deeds are to be delivered up, the following condition may be inserted:

That as the aforesaid lots are holden under the same title, the purchaser of the greater part in value of the said estate shall have the custody of the title-deeds, upon his entering into the usual covenants for the production thereof to the purchaser or purchasers of the remaining or other lots: if the largest portion in value of the estate shall remain unsold, the seller shall be entitled to retain the deeds upon entering into such covenants as aforesaid; all such covenants to be prepared by and at the expense of the person or persons requiring the same, who may have attested copies of such deeds, at his, her, or their own expense.

Condition to be inserted instead of the fourth—if the property to be sold is leasehold.

That within ———— from the day of sale, the vendor shall, at his own expense, prepare and deliver to the purchaser, or his solicitor, an abstract of his title to the property sold, commencing with a lease bearing date the —— day ————, A.D. ———; but he shall not be required to produce the lessor's title, nor shall any enquiry be made into the lessor's title.

Agreement to be signed by the purchaser and to be printed or written on the conditions and particulars.

I have this day purchased of [*name of vendor*] by public auction, lot ———— mentioned in the above-written particulars, for the sum of £ ——, and have paid into the hands of ———— the sum of £ —— as a deposit and in part payment of the said purchase-money; and I do hereby agree to pay the remaining sum of £ —— unto ————, at ————, on or before the ——— day of ————; and in all other respects, on my part, to fulfil the above-written conditions of sale. As witness my hand, this —— day of ————, 185—

Purchase-money
Deposit-money £ ————

Remainder unpaid £ ————

Witness,

Conditions of Sale on Sale of Goods.

1. That the highest bidder shall be the buyer, and if any dispute shall arise, between two or more bidders, the lot shall be put up again and resold.
2. That no person shall advance less at a bidding than ————, or retract his bidding.
3. That every purchaser shall immediately pay to the auctioneer a deposit, at the rate of —— per cent. on the amount of his bidding and in part payment.
4. That the remainder of the purchase-money shall be paid and each lot cleared with all faults at the ——— expense within ——— days from the day of sale.

5. That no error of description shall annul the sale, nor shall any allowance be made for such error.

6. That if the purchaser shall make default either in payment of remainder of the purchase-money, or in clearing the lot or lots purchased by him, according to the above conditions, his deposit-money and all his right and interest in the goods purchased shall be forfeited, and the lot or lots may be re-sold, either by public auction or private contract, at any time within ————————, and if any loss shall arise on such re-sale, the party so in default shall make good the same.

CHAPTER XXIII.

LANDLORD AND TENANT.

SECT. I.—*Agreements and Leases.*

Lawyers only may prepare a "Deed." Non-professional men may prepare an "Agreement."

1. IT has been seen, that by 44 Geo. III., c. 98, none but the lawyers therein specified, can prepare a deed for gain, fee, or reward, but that any person not a lawyer, may prepare an agreement not under seal.

What Lease must be by Deed.

By the conjoint operation of the Statute of Frauds, (29 Car. 2, c. 3, s. 1 and 2,) and the statute 8 & 9 Vict., c. 106, s. 3, all leases for more than three years from the making thereof, must be by deed. By the same statute, the assignment, or surrender in writing of a decree, must be by deed. A lease for three years or less, from the making thereof, need not be by deed. An agreement for a lease for any term is good without deed; and if a tenant is let into possession under such an agreement, he is at first a mere tenant-at-will, and may be turned out upon a demand of possession, or may quit without notice. If he occupies and pays rent for an aliquot portion of a year under such agreement, he becomes tenant from year to year, upon the terms of the agreement, and can only quit or be expelled from possession, by giving or receiving a half year's notice to quit, expiring at the period of his year when his tenancy commenced. If he remains in possession during the whole term mentioned in the agree-

Nature of Tenancy under an "Agreement for a Lease."

ment he may quit, or be turned out without notice to quit.

Obligation of the party refusing to give or take a Lease according to Agreement.

An agreement for a lease renders the party who neglects or refuses to give or take a lease according to its provisions liable to an action at law for compensation in damages or to a bill in equity for a specific performance. It should provide that the intruding lessees shall not call for the lessor's title.

What Agreements are Leases.

Any agreement which provides for the tenant having possession of the land for three years or less from its date, does not contemplate another instrument being executed before possession is given, is a lease, and must be stamped as such.

Stamps upon Agreements.

	s.	d.
2. The stamp upon an agreement for a lease is	2	6
Or if it contains 2160 words, then for every 1080 above the first 1080, a progressive duty of . .	2	6

Stamps upon Leases.

The stamp upon a lease of lands at a yearly rent without premium is—

						s.	d.
If the yearly rent does not exceed			£5	.	.	0	6
If it exceeds	£5	and not	£10	.	.	1	0
„	10	„	15	.	.	1	6
„	15	„	20	.	.	2	0
„	20	„	25	.	.	2	6
„	25	„	50	.	.	5	0
„	50	„	75	.	.	7	6
„	75	„	100	.	.	10	0
„	100	then for each	50	and also for			
every fractional part of			50	.	.	5	0

Leases, on which premiums are paid, and leases of mines on which Royalties are reserved, are subject to other duties, for which see the Stamp Act, 13 and 14 Vic., c. 97.

There is a progressive duty of 10*s.* for every 1080 words beyond the first 1080, if the lease contains 2160 words or upwards.

If the duty on the lease is 5*s.*, or less, the duty on the counterpart is the same as on the lease.

But if the duty on the lease exceeds 5*s.*, the counterpart may be stamped with a 5*s.* stamp, and a progressive duty of 2*s.* 6*d.* for every 1080 words beyond the first 1080, if it contains 2160 words. But this counterpart must have a denoting stamp, and can only be so stamped, on production of both instruments, duly executed and duly stamped.

Ordinary Tenancy from year to year.

3. The ordinary tenancy of lands, houses, &c., is a tenancy from year to year. This tenancy is implied by law: 1st, where lands, &c., are let at annual rent, and it is not expressed how long the tenancy is to last.

2nd. Where a tenant holds over, after the expiration of a lease, or other tenancy, for a definite term, and pays rent for a year, or an aliquot part of a year, as a quarter.

3rd. Where a tenant enters into possession under an agreement to purchase, as an agreement for a lease, and pays rent in like manner.

In the two last cases, the payment and acceptance of rent raises an inference that the tenancy is to last for a definite period, and when no other period is defined, the presumed term is from year to year.

Determination of Tenancy.

If the tenancy is for a year, or other prescribed period, the tenant is bound to quit at the end of the the term without notice; but if the tenancy is from year to year, it can only be determined by a notice to quit expiring at the period of the year when the tenancy commenced, unless it is otherwise expressed in the agreement.

If a tenant holds as tenant from year to year under an agreement for a lease for a certain term of years, his tenancy may be determined at the expiration of any year during the term by a six months' notice to quit; but at the end of the term mentioned in the agreement, he is bound to quit without notice.

If the tenancy is for a year, and so on from year to year so long as the parties please, it is a tenancy for two years at the least (Doe d. Chadborn *v.* Green, 9 A. R., 658; Reg. *v.* Chawton, 1 G. B., 247). But a tenancy from year to year so long as both parties please, may be put an end to at the end of the first year. (Doe d. Clarke *v.* Smaridge, 7 G. B., 957; Doe d. Plumer *v.* Mainby, 10 G. B., 473.)

Covenants of an "Agreement for a Lease."

4. In agreements for leases, the term, the rent, the times of payment, and all the covenants upon which the tenant is to hold, should be mentioned. It should also be stated at whose expense the lease and counterpart is to be prepared, and that the intended lessees shall not enquire into the lessor's title.

Covenants of Leases.

5. In agreements for tenancies, which in law are leases, the latter stipulations as to preparation of a lease, and the landlord's title, are unnecessary.

6. A lease should specify the time from which the term

Commencement and length of term.

is to commence, and the term during which the tenant is to hold the premises; if this is mentioned, the tenant is bound to quit at the end of the term without notice to quit.

Rent and times of payment.

7. The rent payable and the times of payment. If an annual rent is reserved, and no time of payment mentioned, it is not payable until the end of the year: therefore, if the intention is that the rent should be payable quarterly or half yearly, it is necessary expressly to mention it.

Rates and Taxes.

8. The property tax, land tax, and sewers rate imposed on the rent, are taxes on the rent; and the tenant is entitled to deduct so much of such taxes as are rated on the rent from it. But if the premises are rated at a higher value than the rent, he cannot deduct the whole of such taxes. An agreement that the tenant shall pay the landlord's property tax, is not binding; but it is lawful for the tenant to agree to pay the land tax and sewers rate. The property tax and land tax must be deducted from the rent, which is paid next after such taxes have been paid. If the deduction is not then claimed, the landlord is not bound to allow such taxes out of a subsequent arrear of rent. Other taxes and rates, such as the house tax and parish rates, are payable by the tenant. If the tenant agrees to pay all rates and taxes or to pay rent clear of all rates and taxes he is bound to pay the land tax and sewers rate.

Repairs.

9. There should also be an agreement to repair. If the agreement to repair is absolute, the tenant is found to rebuild if the premises are destroyed by fire or other accident. (*Gibbons on Dilapidations*, 165.) If this is not the intention an exception should be introduced into the agreement. He is also to pay rent if the premises are destroyed by fire, unless the event is provided for in the agreement. (ib. 168.) A landlord is under no obligation to repair, except by the custom of the city of London, Norfolk, and the Isle of Ely, in which places the landlord is bound to repair in the absence of express agreement binding the tenant to do so. The Landlord is not understood as warranting that the premises are or will continue tenantable during the term; and if they become unsafe or uninhabitable, the tenant cannot claim compensation from the landlord, nor if he quits them in consequence, is he excused from the payment of rent. (ib. 171.)

Agreement to cultivate Lands.

10. In a lease of lands an agreement to cultivate should be inserted. In the absence of express agreement on a

letting of farm lands, an agreement to cultivate according to the custom of the country is implied. (ib. 201.)

As to Assignment and the carrying on particular Trades.

11. If it is intended to restrain the tenant from assigning his interest either absolutely or without license, or from carrying on any particular trades on the premises, an agreement to such an effect should be inserted in the lease. This is especially necessary if the landlord holds under a lease by which certain trades are prohibited.

Non-payment of Rent or breach of Covenant.

12. There should also be a proviso of forfeiture, in the event of non-payment of rent or breach of covenant. This will enable the landlord, in the events provided for, to put an end to the tenancy, and recover possession.

Lease for three years, or less, of a House.

Lease made the ———— day of ————, 18 ——, between ————, of ————, of the one part, and ————, of ————, of the other part.

The said ———— lets, and the said ———— takes the messuage or tenement, and premises numbered———, in ———— street, in the parish of ————, in the county of ————, with the appurtenances, for the term of three years from the ——— day and year above-mentioned*.

The rent to be £ —— a year, payable quarterly, without deduction or abatement, on any account whatever, on the usual quarter days ———— : the first quarterly payment to become due and be made on the ——— day of ———— next.

Should the premises be burnt down or rendered uninhabitable by accidental fire, the rent to be suspended until they are repaired by the landlord so as to be habitable, and the tenant on the quarter-day subsequent to the fire, to pay a proportion of the rent calculated up to the day of the fire; and on the quarter-day subsequent to the repair of the premises, to pay a proportion of the rent, calculated from the day of such repair, up to next subsequent quarter-day.

* Or some day before. If it is to hold for three years from the day subsequent to the making the lease must be by deed.

The tenant to keep and leave the premises in as good repair and condition as the same now are in, reasonable wear and tear, and accidents by tempest or fire only excepted.

The tenant to pay all rates and taxes assessed or imposed on the premises during his tenancy, or on the landlord or tenant in respect thereof, including land tax, sewers rate, and water and gas rate, but excepting the landlord's property tax.

The tenant not to assign or underlet without the license in writing of the landlord, nor to carry on any of the following trades * * * * * * *

If the tenant shall neglect to pay the rent within twenty-one days after it shall become due, although it be not demanded, or if he shall desert the same, and leave the same, without a sufficient distress for a quarter's rent, whether any rent shall be in arrear or not; and if he shall make breach of, or fail to perform any of the above agreements, this demise shall be void, and it shall be lawful for the landlord, his heirs, executors, administrators, or assigns, to re-enter and re-take possession of the premises.

The tenant has paid to the landlord £ ——— for the fixtures mentioned in the schedule; and the landlord agrees to re-purchase the said fixtures at the end of the tenancy, at their value, not exceeding the said sum of £ ——, such value to be ascertained, in case of disagreement, by two brokers, one to be named by each party or their umpire.

Should the tenancy continue beyond the term herein mentioned, it may be determined by a quarter's notice, expiring at any quarter day.

Schedule of Fixtures.

[The Schedule should be written on the same paper, or annexed to the lease. If not, it requires a schedule stamp.]

Agreement for a Farm.

Agreement between ————————————, of ————————————, and ———————— ———, of ————————————, for letting a farm in the parish of ————————————, in the county of ————, the particulars whereof are mentioned in the schedule hereunder written.

1. Term to be ——— years, to be computed from the

———— day of ————, and if the tenancy continues beyond that time, the same to be determined on the ———— day of————, in any year, by six calendar months' notice in writing, to be given by either party to the other.

2. Rent to be £ ——— per annum, to commence from the ———— day of ———— next, and be paid quarterly on the usual quarter days.

3. The landlord reserves to himself all timber and timber-like trees. He also reserves to himself and any person authorised by him the right of sporting over the premises.

4. The tenant to pay and discharge all land-tax, rates, taxes, tithes, and rent-charges in lieu of tithes, and other outgoings of every description, except the landlord's property tax.

5. The tenant not to plough or convert to tillage any part of the premises described in the said schedule to be meadow or pasture, without the consent in writing of the landlord, or his agent; nor sow or plant flax, rape, hemp, or teasels, upon any part of the said premises, under an additional sum, at the rate of £20 per acre, per annum, to be payable quarterly, on the days aforesaid, and to be considered as rent, and payment thereof to be enforceable accordingly.

6. The tenant not at any time between the 1st day of November, and the 1st day of April, to depasture or feed more than two horses, mares, or geldings, in any one close, at any one time, after giving or receiving notice to quit the same.

7. The landlord to keep in repair the roofs, walls, beams, and stanchions of the dwelling-house and out-houses, belonging to the said premises.

8. The tenant not to sell or part with any dung or compost to be made on the premises, nor any hay, straw, halm, or stubble, or the fodder that shall arise therefrom, but to spend and consume the same on the premises.

9. The tenant not to let or in any manner otherwise dispose of or permit to be occupied by any other person, any part of the premises, without the landlord's consent in writing.

10. The tenant to keep in repair the glass of the windows of the dwelling house, and to do all internal repairs

and painting; and also to repair all gates, posts, stiles, rails, pales, and backings; and the hedges, walls, and other fences, and to cleanse the ditches, watercourses, and drains.

11. The tenant not to mow any part of the meadow lands more than once in any year, or after the 10th day of August, in every year; and in all respects to manage and cultivate all the premises in a husbandlike manner.

12. The landlord to have and take immediate possession of the premises, in case the tenant shall be adjudged bankrupt, or in case he shall take the benefit of any act for the relief of insolvent debtors, or shall permit any writ of execution to be levied on his effects; or if the rent shall be in arrear for twenty-one days after any quarter-day, and there shall not be sufficient distress on the premises, or if the tenant shall make a breach of, or neglect to perform any of the above stipulations.

In witness whereof the said parties to these presents have hereunto set their hands, the ———— day of ————————, 185

Witness,

———————————

———————————

The Schedule by the foregoing terms referred to.

No. on Map.	Description of Premises.	Culture.	Quantity. A.	R.	P.	Observations.

SECT. II. —*Notice to Quit.*

When necessary.

1. A Notice to Quit is necessary in all cases when the tenant holds as tenant from year to year, or from month to month, or from week to week, or for a continuing term not precisely defined; but not if he holds for a precise term or at will.

Length of Notice.

2. If the holding is from year to year, the notice must expire at the end of the current year. It may either be given 182 days before the end of the current year, or prior to, or on the corresponding feast, which happens two quarters before the feast on which the current year ends, as on Michaelmas-day, to quit on Lady-day. (Doe d. Harrop *v.* Green, 4 Esp., 199.)

If the tenancy is quarterly, or monthly, or weekly, it may be determined by a quarter's, a month's, or a week's notice expiring at the end of any quarter, month, or week, of the tenancy.

When Tenancy is considered as commencing.

3. In general the tenancy is understood as commencing from the time of the tenant's entering, and the notice to quit must expire at that period of the year; but if his quarterly or yearly rent is calculated from the quarter-day preceding or succeeding his entry, his tenancy will be taken to commence on such quarter-day. (Doe d. Holcomb *v.* Johnson, 6 Esp., 10.) If the yearly tenancy arises from a holding over, after the expiration of a lease, it dates from the time when the lease ended. If different parts of the premises are held from different times as is often the case in farms, it is sufficient if the notice is given a half year before the day on which the first year's rent is payable, or on which the tenancy of the principal part of the premises commenced. (Dugget *v.* Snowden, 2 Black., 1224; Doe d. Ld. Bradford *v.* Watkins, 7 East., 551.)

By whom Notice is to be given.

4. A notice to quit may be given by an agent, but he must have authority at the time he gives the notice. An agent to let and receive rents has authority to give a notice to quit; but a mere agent to receive rents has not. One of several joint tenants may give a notice to quit. But the notice of one of several co-partners or tenants in common, without authority from the others, only determines the tenancy of his share.

To whom to be given, and Service.

5. It should be given to the tenant himself or to his assignee, not to a sub-tenant. If served on the person in

possession of the premises, it will be presumed that he is assignee of the original tenant in the absence of proof to the contrary. It may be served on the wife or servant of the tenant on the premises.

Form of Notice.

6. The notice should be explicit, and not give the tenant the option of entering into a new contract. But a notice to quit, or "I shall insist on double rent," is not bad on this ground, as it merely intimates the legal consequence of the tenant holding over. It should also be precise as to the time of quitting. A notice to quit at "the end of the current year of your tenancy," when the current year ends within a half year from the notice, is bad; but a notice to quit "at the end of the current year of your tenancy, which will expire next after a half year from the service of this notice," is good, and the proper form to adopt in all cases where the time of the commencement of the tenancy is not known or cannot be proved.

Waiver of Notice.

7. A notice to quit is waived by receiving or distraining for rent accruing due after the expiration of the notice.

Holding over after the Landlord's Notice.

8. If a tenant wilfully holds over after the termination of his term, and after demand made and notice in writing given for delivering possession by the landlord or his agent, he is liable to pay to the person kept out of possession for the time he holds over, at the rate of double the yearly value of the lands detained. (4. Geo. 2., c. 28.) This provision applies to a tenant holding over after notice to quit given by the landlord, and such notice is a sufficient notice and demand of possession under the statute.

Holding over after the Tenant's Notice.

9. If the tenant holds over after a notice to quit given by himself, he is liable to pay double rent, which may be distrained for. (11 Geo. 2, c. 19, s. 18.)

Form of Notice to Quit.

Mr. [*Tenant's name.*]

I hereby give you notice, to quit and deliver up on the* ——— day of ——————— next, the possession of the dwelling-house [or ———] with the appurtenances which you now hold of me†, situate in the parish of ——— ———, in the county of ———, provided your tenancy originally commenced at that time of the

* Day on which tenancy expires.

† If notice is signed by an agent, here insert landlord's name.

year, or otherwise, that you quit and deliver up the possession of the said dwelling-house, &c. at the end of the year of your tenancy, which shall expire next after the end of one-half-year from the time of your being served with this notice; and further take notice, that unless you quit at the expiration of this notice, you will be liable to pay double the yearly value of the premises held over, for so long as you shall hold over the same.

Dated this ——— day of———————, 185—.

Yours, &c.

Sect. III.—*Distress.*

Nature of Distress, and in what cases it may be made.

1. A Distress is a right to seize goods to enforce payment of rent. The landlord distraining must have a reversion, that is an interest and right to possess the premises after the determination of the tenancy to which the rent is incident. There must also be a tenancy for a term certain, at a rent certain. A person let into possession under a mere agreement for a lease, who is only tenant at will and may be ejected at his landlord's pleasure, or may quit at his own, cannot be distrained on until he has become tenant from year to year, by payment of rent.

At what time.

2. A distress must be made during the term, or within six calendar months after its determination, during the landlord's interest and the tenant's possession (8th Ann, c. 14, s. 6 & 7.) It must be made in the day-time between sunrise and sunset. It cannot be made until the day after that on which the rent is payable.

At what place.

3. The goods distrained must be taken on the premises from which the rent issues. If the goods of the tenant are fraudulently removed from the premises after the rent has become due, the landlord may follow and distrain them within thirty days after the removal, provided they have not, before seizure, been bonâ fide sold for a valuable consideration. The tenant and all persons wilfully assisting him in removing or concealing the goods, are liable to a penalty in double the value of the goods, and if the value of the goods does not exceed £50, the penalty may be recovered before two justices. If the goods removed are locked up in any house or other place, the landlord or his bailiff may, in the day-time, break open and enter the house or place, first calling to his assistance the constable of the

place, and in the case of a dwelling house, making oath of a reasonable ground to suspect that the goods are in such dwelling-house (11 Geo. II., c. 19, s. 1 to 7.)

What Goods are Distrainable.

4. All goods on the premises, with certain exceptions, may be distrained for rent, also cattle and stock on a common, appendant appurtenant, or in any ways belonging to the premises—growing corn, grass, hops, fruits, pulse, and other produce, may also be distrained and may be cut when ripe, and laid up in barns on the premises, and in convenient time may be appraised and sold. Notice of the place where the crops are lodged must be given to the tenant within one week after they are lodged. If the tenant pays or tenders the rent and expenses before the crops are ripe and cut, cured, or gathered, the distress is to cease (11 Geo. II., c. 19, s. 8 & 9.)

Goods absolutely privileged from Distress. Goods in the Custody of the Law.

5. Goods privileged from distress are 1st, goods in the custody of the law, that is, goods already under distress or under execution. In this latter case, the execution creditor is bound to pay the landlord the rent due at the time of the seizure, not exceeding one year's rent, before the goods can be removed under the execution (8th Ann, c. 14.)

Fixtures.

6. 2ndly, Fixtures or things fixed to the freehold, such as grates, doors, windows, and the like: a temporary disunion of a fixture does not render liable to a distress, as if a mill-stone is removed for the purpose of being picked.

Things part of the Demise.

7. 3rdly, Things which are part of the demise as the furniture of a furnished lodging.

Things not the subject of Property.

8. 4thly, Things which are not the subject of property, as wild animals, but tame animals such as cattle, dogs, tame deer, or deer in an inclosure kept for profit, may be distrained. (Davies *v.* Powell Willes, 50.)

Perishable Things, and Things which cannot be identified.

9. 5thly, Things which cannot certainly be identified and cannot be returned in the same state, such as loose money, meal, or the like, and things which quickly perish, such as meat and milk, are not distrainable, because they cannot be returned in the same state. But by W. & M., c. 5, s. 3, sheaves of corn, or corn loose or in the straw, or hay in any barn or granary, or in any hovel, stack, or rick or otherwise, upon any part of the land may be distrained, and locked up and detained in the place where found, until replevied or sold.

Goods delivered for pur-

10. 9thly, things delivered to a person exercising a

public trade to be carried, wrought, or managed in the way of his trade: under this head, a horse sent to a farrier to be shoed, goods sent to an auctioneer to be sold, or an ox sent to a butcher to be slaughtered, are exempt from being distrained, so the horses and carriages of a guest standing at an inn are privileged; but horses and carriages at a livery stables are not. (Parsons *v.* Gingell, 4 C. B., 545.)

poses of Trade.

7thly, Things in actual use are privileged, because to take such things may provoke a breach of the peace, for instance, an axe in a man's hand, a horse on which he is riding, a cart in which he is standing, a loom at which he is working.

Goods in use.

8thly, Cattle on their way to market, put on the land for their necessary refreshment, with the privity of the lessor or the lessee, are privileged. So cattle which escape into the land because there are not sufficient fences, unless the owner of the cattle is bound to keep up the fences, are privileged, until they have been levant and couchant on the tenant's land (which means until they have been there a whole night). If the landlord or tenant of the land into which the cattle escape is bound to keep up the fences, they are not distrainable unless notice has been given to the owner of his cattle having strayed, and he has neglected to remove them for a reasonable time after such notice. In no case can stray cattle be distrained for rent, if the owner has made fresh pursuit and endeavoured to bring them back.

Cattle on their way to Market.

Implements of husbandry, and beasts of the plough, saddle horses, poultry, implements of trade, wearing apparel and jewels, should not be distrained if there is other sufficient distress.

Things privileged conditionally.

In making a distress no outer door or window can be broken, nor can the door of a barn or stable.

Manner of Distraining, not to break outer door.

The goods must be seized and impounded; they may be, and usually are, impounded and sold on the premises (11 Geo. II, c. 19, s. 10,) where this is done, they are considered as impounded as soon as seized. They cannot be impounded out of the county in which they are taken, (stat. Marlbridge, 52, Hen. III, c. 4), nor out of the hundred except in a pound in the same county, and not above three miles from the place of the distress, under a penalty of £5 and treble damages. If the rent is tendered before the distress is impounded, either to the

Impounding and tender of Rent.

landlord or to the bailiff making the distress (Hatch *v.* Hale, 15 G. B., c. 10,) it must be accepted. But after the distress is impounded, the landlord is bound to accept the rent and costs if tendered.

Sale.

A distress cannot be sued by stat. 2, W. & M., sess. 1, c. 5, if the tenant does not replevy within five days next after distress taken, and notice thereof left at the chief mansion house or other most notorious place on the premises, the person distraining may, with the sheriff or under-sheriff of the county, or the constable of the hundred, parish or place, where the distress has been taken, cause the goods distrained to be appraised by two sworn appraisers (whom such sheriff, under-sheriff, or constable must swear to appraise the same truly according to the best of their understanding,) and after such appraisement, may sell the same for the best price that can be gotten for them, for satisfaction of the rent and charges of the distress, appraisement, and sale, leaving the overplus, if any, with the sheriff, under sheriff, or constable, for the owner's use.

Notice of Distress and Appraisement.

The notice must be in writing (Wilson *v.* Nightingale, 8 G. B., 1034.) It must specify the goods distrained. It is sufficient to say that all goods on the premises are distrained (Wakeman *v.* Lindsay, 19 L. J. G. B., 166), but not sufficient to say all goods on the premises that may be required to satisfy the rent and expenses, (Kirby *v.* Harding, 6 Ex., 234.) Five clear days must elapse after the day of the distress and notice given, before the goods can be appraised or sold. (Robinson *v.* Waddington, 13 Q. B., 753.) The appraisers must be two persons having no interest in the matter, the distraining broker cannot be one. (Westwood *v.* Cowne, 1 Stush., 172.) There must be two appraisers, although the rent is under £20. (Allen *v.* Flicker, 10 A. V. E., 640.)

Irregularities in Distress.

The distress should not be excessive. The mere circumstance of the distress being for more rent than due, does not render the landlord liable to the tenant unless some special damage has been sustained by him. (Tancred *v.* Leyland, 16 G. B., 669.) There cannot be a second distress for the same rent, unless the value of the first distress, is found insufficient. (17th Jas. II, c. 7, s. 4; Dawson *v.* Cropp, 1 C. B., 961.)

Costs of Distress.

By 57 Geo. III, c. 93, no person making a distress

for rent, when the sum demanded and due does not exceed £20, can take, either from the tenant or the landlord, any other or more charges for any matter or thing done in the distress, than are mentioned in the schedule to the act, or can make any charge for any act mentioned in the schedule, unless the act has been really done. If he violates the act, a justice of the peace may order him to pay treble damages and costs to the party grieved, which may be levied by distress warrant; in case of no sufficient distress, he may be committed to gaol, until he pays or satisfies the order; if the complaint is unfounded, the complainant may be ordered to pay costs. The landlord is not liable under this statute, unless he personally levies the distress. Every broker who makes a distress must give a copy of his charges, although the rent demanded exceeds £20.

The schedule of charges are:—

Levying Distress	0	3	0
Man in possession, per day	0	2	6
Appraisement 6*d.* in the pound on the value of the goods			
Stamp, the lawful amount thereof .			
All expense of advertisements if any such	0	10	0
Catalogues, sale and commission, and delivery of goods 1*s.* in the pound on the net produce of sale . . .			

The provisions of this statute are extended to distresses for land tax, assessed taxes, poors rates, church rates, tithes, highway rates, sewer rates, or any other rates or taxes, if the sum demanded and due does not exceed £20, and to all cases in which the whole of several sums sought to be levied by distresses, taken for different purposes at the same time, do not exceed the sum of £20. (7 & 8 Geo. IV., c. 17.)

Right of Distress on Bankruptcy or Insolvency of Tenant.

In the event of the bankruptcy or insolvency of the tenant, the landlord's remedy by distress is limited to one year's rent due at the time of the bankruptcy or insolvency, if more is due he must come in as a creditor. (12 & 13 Vict., c. 106, s. 129; Bankrupt act, 1 & 2 Vict., c. 110, s. 58; Insolvent debtor's act, persons in prison for debt who petition for their discharge, 7 & 8 Vict., c. 96, s. 18; Protection act, insolvents who petition for protection from process.)

Warrant of Distress.

To Mr. ————————, my bailiff. Distrain the goods and chattels of ————————, (the tenant,) in the house he now dwells in, (or on the premises in his possession,) situate in ————————, in the county of ————————, for ———— pounds, being one year's rent due to me for the same at ———— day last, and for your so doing this shall be your sufficient warrant and authority; and in consideration of your so doing, I hereby undertake to indemnify against loss, costs, charges, damages, or expenses which you may thereby incur *or sustain,* and against any action or proceeding, lawful or unlawful, which may be brought against you for acting in obedience to this warrant. Dated this ———— day of ————185—.

Notice of Distress.

Mr. ————————,
Take notice, that I have this day distrained (or that as bailiff to ————, your landlord, I have this day distrained) on the premises above-mentioned, the several goods and chattels specified in the inventory hereunder written, for the sum of ————————, being one year's rent due to me (or to the said ————————,) at ———— day last, for the said premises, and that unless you pay the said rent, with the charges of distraining for the same, or replevy the said goods and chattels within five days from the date hereof, they will be appraised and sold according to law. Given under my hand the ———— day of ————, in the year 18—.

Consent by Tenant to hold over.

Memorandum. That I, ————————,
do hereby consent and agree that ————————,
my landlord, who hath distrained my goods and chattels for the rent in a dwelling-house, ————————,
situate at ————, in the county of ————,
shall continue in the possession of my said goods and chattels, in the said dwelling-house, ————, for the space of ———— days from the date hereof, the said ———— having agreed to forbear the sale of the said goods and chattels for the said space of time, to

enable me to discharge the said rent; and I, the said ————————————, do hereby agree to pay the expenses of keeping the said possession.

As witness my hand the ———— day of ————————, in the year of our Lord, 18—.

Witness,

Notice of Distress of Standing Corn.

Take notice, that I have this day, as bailiff of ———— ————————, your landlord, taken and distrained on the premises undermentioned, the several growing crops specified in the inventory underwritten, for the sum of £ ————, being one year's rent due to the said ————————, at ———————— day last, for the said premises, and unless you previously pay the said rent, with the costs of distraining the same, I shall proceed to cut, gather, make, cure, carry, and lay up the crops, when ripe, in the barn, or other proper place on the said premises, and in convenient time sell and dispose of the same, towards satisfaction of the said rent, and of the costs of the distress, appraisement, and sale, according to the form of the statute in that case made and provided. Given under my hand this ———————— day of ————————————, 18—.

Appraiser's Oath.

You and each of you shall well and truly appraise the goods and chattels mentioned in this inventory (holding it up in his hand) according to the best of your judgment. So help you God.

Appraisement.

We, the above-named, ————————————, and ————————————, being sworn upon the Holy Evangelists, by ————————————, the constable above-named, well and truly to appraise the goods and chattels mentioned in this inventory, according to the best of our judgment, and having viewed the said goods and chattels, do appraise the same at the sum of———————— pounds. As witness our hands the ———————— day of ————————————, in the year of our Lord 18—.

————————————
————————————
} *Sworn Appraisers.*

SECT. IV.—*Recovery of Possession.*

Right of Entry.

In all cases where the interest of the tenant has expired, the landlord has a right by law to enter and take possession, and may do so without resorting to any legal proceeding, if he can, without disturbing the public peace. But if the tenant is in possession, and is likely to resist the landlord's entry, it is advisable to proceed at law, as although the tenant can maintain no action, the landlord may render himself liable to an indictment for a forceable entry. (See Davison *v.* Wilson, 11 G. B., 890.)

If Premises are Deserted.

If a tenant holding lands, &c., at a rack rent, or a rent which is full three-fourths of the yearly value of the demised premises is in arrear for a half-year's rent, and deserts the premises, and leaves them uncultivated, or unoccupied, so as no sufficient distress can be had to countervail the arrears of rent, two or more justices of the peace of the county, riding, division, or place having no interest in the demised premises, at the request of the landlord, his bailiff or receiver may go upon and view the same, and affix, or cause to be affixed, on the most notorious part of the premises, notice in writing, stating what day, (at the distance of fourteen days at the least,) they will return to take a second view thereof, and if upon such second view, the tenant, or some person on his or her behalf, does not appear and pay the rent in arrear, or there is not a sufficient distress on the premises, the justices may put the landlord into possession of the demised premises, and the lease thereof, as to any demise therein contained, only becomes void. This proceeding may be taken, although there is no right or power of re-entry reserved in the lease to the landlord upon non-payment of rent. The tenant may appeal to the next justice or justices of assize of the county in which the lands lie, or if in London or Middlesex, to the judges of the Queen's Bench or Common Pleas, or if in a County Palatine, before the judges thereof (11 Geo. 2, c. 19, s. 16 & 17; 57 Geo. 3, c. 52.)

If the premises are within the Metropolitan Police District, a police magistrate, at the request of the landlord, his bailiff, or receiver, made in open court, and upon proof given to the satisfaction of the magistrate of the arrear of rent and desertion of the premises, may issue his warrant

directed to the police constable, requiring him to go upon and view the premises, and affix the notices, and upon return of the warrant and proof that it has been duly executed, and that neither the tenant nor any person on his behalf has appeared and paid the rent, and that there is not sufficient distress on the premises, the magistrate may issue his warrant to a police constable, requiring him to put the landlord into possession. (3 & 4 Vict., c. 84, s. 13.)

Before a Magistrate, if Rent not more than £20.

If the interest of a tenant holding at will, or for any term not exceeding seven years, either without rent, or at a rent not exceeding £20, and upon which no fine has been reserved or made payable, has ended or been duly determined by a legal notice to quit, or otherwise, and the tenant, or any person by whom the premises or any part is occupied, neglects or refuses to quit and deliver up possession, the landlord or his agent may cause the person so neglecting or refusing to be served with a written notice, in form set forth in the schedule; and if the tenant or occupier does not appear at the time and place appointed, and show to the satisfaction of the justices reasonable cause why possession should not be given, and still neglects or refuses to deliver possession, the landlord or his agent may give the justices proof of the holding and of the end or determination of the tenancy, with the time or manner thereof, and if the title of the landlord has accrued since the letting, the right by which he claims possession, and upon proof of the service notice, and the neglect or refusal of the tenant or occupier, the justices acting for the district, division, or place within which the premises or any part thereof are situate, in petty sessions assembled, or any two of them may issue a warrant under their hands and seals to the constables and peace officers of the district, division, or place, within which the premises, or any part thereof, are situate, commanding them within a period therein named, not less than twenty-one nor more than thirty clear days from the date of the warrant, to enter by force if needful and give possession thereof to the landlord or agent. The warrant must be executed between nine in the morning, and four in the afternoon, and not upon Sunday, Good Friday or Christmas-day, an action of trespass may be brought against the party applying for the warrant, if there is no right of entry. Any rights which the tenant may be entitled to, as outgoing

tenant by custom of the country, or otherwise, are not affected by the proceeding. The notice of application may be served either personally or by leaving the same with some person, being in, and apparently residing at, the place of abode of the person holding over. The person serving the notice must read it over to the person served, and explain the purport and intent. If the person holding over cannot be found, and his place of abode is not known, or admission thereto cannot be obtained for serving the summons, the posting it up on some conspicuous part of the premises held over is good service.

If the party to whom the warrant is granted has not at the time a lawful right to enter, the obtaining of the warrant is an act of trespass. The execution of the warrant is to be stayed if the tenant, with two sureties to be approved of by the justices, enters into a bond to try an action of trespass and pay the costs if unsuccessful. If he succeeds in the action, the warrant is suspended. The bond is to be given to the landlord or his agent, and to be prepared at his (the landlord's or agent's) costs, and is to be deemed forfeited, unless the judge at the trial, indorses on the record that the condition has been fulfilled. The Court in which the action is brought may relieve the parties from the bond.

No action can be brought against the justices for granting, or the constables for executing the warrant (1 & 2 Vict. c. 74).

In County Court, if Rent not more than £50.

The County Courts have jurisdiction to give possession to a landlord in all cases when the term or interest of the tenant of premises the value or the rent payable in respect of which does not exceed £50 by the year, and upon which no fine has been paid, has ended or been duly determined by a legal notice to quit if the tenant or person in occupation neglects or refuses to quit and deliver up possession of the premises or any part thereof. The proceeding in the County Court is by plaint, upon which a summons issues; and if the tenant or occupier does not appear and show cause to the contrary upon similar proof, as is required by 1 & 2 Vict., c. 72, the County Court may grant a warrant to the bailiff, to the same effect as the warrant to the constable under the former statute, which has the same effect and must be executed, or may be suspended in the same manner as the magistrates' warrant, (9 & 10 Vict., c. 95, s. 122, 3, 4, 5, 6, 7.)

Form of Notice of Owner's Intention to apply to Justices to recover Possession, under 1 & 2 *Vict. c.* 74.

I ——————, owner (*or* agent to the owner *as the case may be*), do hereby give you notice, that, unless peaceable possession of the tenement, (*shortly describing it,*) situate ——————, which was held of me (*or* of the said ——————, *as the case may be,*) under a tenancy from year to year *or* (*as the case may be*) which expired (*or* was determined) by notice to quit from the said ——————, (*or otherwise as the case may be,*) —————— on the —— day of ——————, and which tenement is now held over and detained from the said —— ——, be given to (the owner *or* agent) on or before the expiration of seven clear days from the service of this notice, I, ——————, shall, on —————— next, the —— day of ——, at —— of the clock the same day, apply to Her Majesty's Justices of the Peace, acting for the district of ——————, (*being the district, division, or place, in which the said tenement, or any part thereof, is situate,*) in Petty Sessions assembled, to issue their warrant directing the constables of the said district, to enter and take possession of the said tenement, and to eject any person therefrom.

Dated this ——————,

(*Signed*)——————,

(Owner *or* Agent.)

To Mr. —— ——.

Complaint before two Justices.

The complaint of —————— (owner *or* agent, &c., *as the case may be*) made before us two of her Majesty's Justices of the peace acting for the district of —— —— in Petty Sessions assembled, who saith that the said —————— did let to —————— at enement consisting of ——————, for ——————, under the rent of ——————, and that the said tenancy expired (*or* was determined by notice to quit given by the said —————— *as the case may be*), on the —————— day of ——————, the said —————— did serve on (*the tenant overholding*) a notice in writing of his intention

to apply to recover possession of the said tenement (a duplicate of which notice is hereto annexed) by giving, &c., *(describing the mode in which the service was effected,)* and that notwithstanding the said notice, the said ———— ————, refused (*or* neglected) to deliver up possession of the said tenement and still detains the same.

(Signed) ————————

Taken the ———— day of ———— before us.

(Signed) ————————

[*A duplicate of the notice of intention to apply is to be annexed to this complaint.*]

Warrant to Peace Officers to take and give Possession.

Whereas, (*set forth the complaint,*) we, two of Her Majesty's Justices of the Peace, in Petty Sessions assembled acting for the ————————, of ————, do authorize and command you on any day within ——— days from the date hereof, (except on Sunday, Christmas Day, and Good Friday, *to be added if necessary,*) between the hours of nine in the forenoon and four in the afternoon, to enter (by force if needful and with or without the aid of ————————, the owner *or* agent, *(as the case may be,)* or any other person or persons whom you may think requisite to call to your assistance, into and upon the said tenement, and to eject thereout any person, and of the said tenement full and peaceable possession to deliver to the said ————————, (the owner *or* agent).

Given under our hands and seals this —— day of———,

To ———————— and all other
constables and peace officers acting
for the district of ————————.

CHAPTER XXIV.

TABLES

OF

NATURAL SINES AND COSINES;

AND

ADDITIONAL USEFUL TABLES.

	0°		1°		2°		
′	N. sin	N. cos	N. sin	N. cos	N. sin	N. cos	′
0	00000	1.00000	01745	99985	03490	99939	60
1	00029	1.00000	01774	99984	03519	99938	59
2	00058	1.00000	01803	99984	03548	99937	58
3	00087	1.00000	01832	99983	03577	99936	57
4	00116	1.00000	01862	99983	03606	99935	56
5	00145	1.00000	01891	99982	03635	99934	55
6	00175	1.00000	01920	99982	03664	99933	54
7	00204	1.00000	01949	99981	03693	99932	53
8	00233	1.00000	01978	99980	03723	99931	52
9	00262	1.00000	02007	99980	03752	99930	51
10	00291	1.00000	02036	99979	03781	99929	50
11	00320	.99999	02065	99979	03810	99927	49
12	00349	.99999	02094	99978	03839	99926	48
13	00378	.99999	02123	99977	03868	99925	47
14	00407	.99999	02152	99977	03897	99924	46
15	00436	.99999	02181	99976	03926	99923	45
16	00465	.99999	02211	99976	03955	99922	44
17	00495	.99999	02240	99975	03984	99921	43
18	00524	.99999	02269	99974	04013	99919	42
19	00553	.99998	02298	99974	04042	99918	41
20	00582	.99998	02327	99973	04071	99917	40
21	00611	.99998	02356	99972	04100	99916	39
22	00640	.99998	02385	99972	04129	99915	38
23	00669	.99998	02414	99971	04159	99913	37
24	00698	.99998	02443	99970	04188	99912	36
25	00727	.99997	02472	99969	04217	99911	35
26	00756	.99997	02501	99969	04246	99910	34
27	00785	.99997	02530	99968	04275	99909	33
28	00814	.99997	02560	99967	04304	99907	32
29	00844	.99996	02589	99966	04333	99906	31
30	00873	.99996	02618	99966	04362	99905	30
31	00902	.99996	02647	99965	04391	99904	29
32	00931	.99996	02676	99964	04420	99902	28
33	00960	.99995	02705	99963	04449	99901	27
34	00989	.99995	02734	99963	04478	99900	26
35	01018	.99995	02763	99962	04507	99898	25
36	01047	.99995	02792	99961	04536	99897	24
37	01076	.99994	02821	99960	04565	99896	23
38	01105	.99994	02850	99959	04594	99894	22
39	01134	.99994	02879	99959	04623	99893	21
40	01164	.99993	02908	99958	04653	99892	20
41	01193	.99993	02938	99957	04682	99890	19
42	01222	.99993	02967	99956	04711	99889	18
43	01251	.99992	02996	99955	04740	99888	17
44	01280	.99992	03025	99954	04769	99886	16
45	01309	.99991	03054	99953	04798	99885	15
46	01338	.99991	03083	99952	04827	99883	14
47	01367	.99991	03112	99952	04856	99882	13
48	01396	.99990	03141	99951	04885	99881	12
49	01425	.99990	03170	99950	04914	99879	11
50	01454	.99989	03199	99949	04943	99878	10
51	01483	.99989	03228	99948	04972	99876	9
52	01513	.99989	03257	99947	05001	99875	8
53	01542	.99988	03286	99946	05030	99873	7
54	01571	.99988	03316	99945	05059	99872	6
55	01600	.99987	03345	99944	05088	99870	5
56	01629	.99987	03374	99943	05117	99869	4
57	01658	.99986	03403	99942	05146	99867	3
58	01687	.99986	03432	99941	05175	99866	2
59	01716	.99985	03461	99940	05205	99864	1
60	01745	.99985	03490	99939	05234	99863	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	89°		88°		87°		

	3°		4°		5°		
′	N. sin	N. cos	N. sin	N. cos	N. sin	N. cos	′
0	05234	99863	06976	99756	08716	99619	60
1	05263	99861	07005	99754	08745	99617	59
2	05292	99860	07034	99752	08774	99614	58
3	05321	99858	07063	99750	08803	99612	57
4	05350	99857	07092	99748	08831	99609	56
5	05379	99855	07121	99746	08860	99607	55
6	05408	99854	07150	99744	08889	99604	54
7	05437	99852	07179	99742	08918	99602	53
8	05466	99851	07208	99740	08947	99599	52
9	05495	99849	07237	99738	08976	99596	51
10	05524	99847	07266	99736	09005	99594	50
11	05553	99846	07295	99734	09034	99591	49
12	05582	99844	07324	99731	09063	99588	48
13	05611	99842	07353	99729	09092	99586	47
14	05640	99841	07382	99727	09121	99583	46
15	05669	99839	07411	99725	09150	99580	45
16	05698	99838	07440	99723	09179	99578	44
17	05727	99836	07469	99721	09208	99575	43
18	05756	99834	07498	99719	09237	99572	42
19	05785	99833	07527	99716	09266	99570	41
20	05814	99831	07556	99714	09295	99567	40
21	05844	99829	07585	99712	09324	99564	39
22	05873	99827	07614	99710	09353	99562	38
23	05902	99826	07643	99708	09382	99559	37
24	05931	99824	07672	99705	09411	99556	36
25	05960	99822	07701	99703	09440	99553	35
26	05989	99821	07730	99701	09469	99551	34
27	06018	99819	07759	99699	09498	99548	33
28	06047	99817	07788	99696	09527	99545	32
29	06076	99815	07817	99694	09556	99542	31
30	06105	99813	07846	99692	09585	99540	30
31	06134	99812	07875	99689	09614	99537	29
32	06163	99810	07904	99687	09642	99534	28
33	06192	99808	07933	99685	09671	99531	27
34	06221	99806	07962	99683	09700	99528	26
35	06250	99804	07991	99680	09729	99526	25
36	06279	99803	08020	99678	09758	99523	24
37	06308	99801	08049	99676	09787	99520	23
38	06337	99799	08078	99673	09816	99517	22
39	06366	99797	08107	99671	09845	99514	21
40	06395	99795	08136	99668	09874	99511	20
41	06424	99793	08165	99666	09903	99508	19
42	06453	99792	08194	99664	09932	99506	18
43	06482	99790	08223	99661	09961	99503	17
44	06511	99788	08252	99659	09990	99500	16
45	06540	99786	08281	99657	10019	99497	15
46	06569	99784	08310	99654	10048	99494	14
47	06598	99782	08339	99652	10077	99491	13
48	06627	99780	08368	99649	10106	99488	12
49	06656	99778	08397	99647	10135	99485	11
50	06685	99776	08426	99644	10164	99482	10
51	06714	99774	08455	99642	10192	99479	9
52	06743	99772	08484	99639	10221	99476	8
53	06773	99770	08513	99637	10250	99473	7
54	06802	99768	08542	99635	10279	99470	6
55	06831	99766	08571	99632	10308	99467	5
56	06860	99764	08600	99630	10337	99464	4
57	06889	99762	08629	99627	10366	99461	3
58	06918	99760	08658	99625	10395	99458	2
59	06947	99758	08687	99622	10424	99455	1
60	06976	99756	08716	99619	10453	99452	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	86°		85°		84°		

′	6°		7°		8°		′
	N. sin	N. cos	N. sin	N. cos	N. sin	N. cos	
0	10453	99452	12187	99255	13917	99027	60
1	10482	99449	12216	99251	13946	99023	59
2	10511	99446	12245	99248	13975	99019	58
3	10540	99443	12274	99244	14004	99015	57
4	10569	99440	12302	99240	14033	99011	56
5	10597	99437	12331	99237	14061	99006	55
6	10626	99434	12360	99233	14090	99002	54
7	10655	99431	12389	99230	14119	98998	53
8	10684	99428	12418	99226	14148	98994	52
9	10713	99424	12447	99222	14177	98990	51
10	10742	99421	12476	99219	14205	98986	50
11	10771	99418	12504	99215	14234	98982	49
12	10800	99415	12533	99211	14263	98978	48
13	10829	99412	12562	99208	14292	98973	47
14	10858	99409	12591	99204	14320	98969	46
15	10887	99406	12620	99200	14349	98965	45
16	10916	99402	12649	99197	14378	98961	44
17	10945	99399	12678	99193	14407	98957	43
18	10973	99396	12706	99189	14436	98953	42
19	11002	99393	12735	99186	14464	98948	41
20	11031	99390	12764	99182	14493	98944	40
21	11060	99386	12793	99178	14522	98940	39
22	11089	99383	12822	99175	14551	98936	38
23	11118	99380	12851	99171	14580	98931	37
24	11147	99377	12880	99167	14608	98927	36
25	11176	99374	12908	99163	14637	98923	35
26	11205	99370	12937	99160	14666	98919	34
27	11234	99367	12966	99156	14695	98914	33
28	11263	99364	12995	99152	14723	98910	32
29	11291	99360	13024	99148	14752	98906	31
30	11320	99357	13053	99144	14781	98902	30
31	11349	99354	13081	99141	14810	98897	29
32	11378	99351	13110	99137	14838	98893	28
33	11407	99347	13139	99133	14867	98889	27
34	11436	99344	13168	99129	14896	98884	26
35	11465	99341	13197	99125	14925	98880	25
36	11494	99337	13226	99122	14954	98876	24
37	11523	99334	13254	99118	14982	98871	23
38	11552	99331	13283	99114	15011	98867	22
39	11580	99327	13312	99110	15040	98863	21
40	11609	99324	13341	99106	15069	98858	20
41	11638	99320	13370	99102	15097	98854	19
42	11667	99317	13399	99098	15126	98849	18
43	11696	99314	13427	99094	15155	98845	17
44	11725	99310	13456	99091	15184	98841	16
45	11754	99307	13485	99087	15212	98836	15
46	11783	99303	13514	99083	15241	98832	14
47	11812	99300	13543	99079	15270	98827	13
48	11840	99297	13572	99075	15299	98823	12
49	11869	99293	13600	99071	15327	98818	11
50	11898	99290	13629	99067	15356	98814	10
51	11927	99286	13658	99063	15385	98809	9
52	11956	99283	13687	99059	15414	98805	8
53	11985	99279	13716	99055	15442	98800	7
54	12014	99276	13744	99051	15471	98796	6
55	12043	99272	13773	99047	15500	98791	5
56	12071	99269	13802	99043	15529	98787	4
57	12100	99265	13831	99039	15557	98782	3
58	12129	99262	13860	99035	15586	98778	2
59	12158	99258	13889	99031	15615	98773	1
60	12187	99255	13917	99027	15643	98769	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	83°		82°		81°		

′	9°		10°		11°		′
	N. sin	N. cos	N. sin	N. cos	N. sin	N. cos	
0	15643	98769	17365	98481	19081	98163	60
1	15672	98764	17393	98476	19109	98157	59
2	15701	98760	17422	98471	19138	98152	58
3	15730	98755	17451	98466	19167	98146	57
4	15758	98751	17479	98461	19195	98140	56
5	15787	98746	17508	98455	19224	98135	55
6	15816	98741	17537	98450	19252	98129	54
7	15845	98737	17565	98445	19281	98124	53
8	15873	98732	17594	98440	19309	98118	52
9	15902	98728	17623	98435	19338	98112	51
10	15931	98723	17651	98430	19366	98107	50
11	15959	98718	17680	98425	19395	98101	49
12	15988	98714	17708	98420	19423	98096	48
13	16017	98709	17737	98414	19452	98090	47
14	16046	98704	17766	98409	19481	98084	46
15	16074	98700	17794	98404	19509	98079	45
16	16103	98695	17823	98399	19538	98073	44
17	16132	98690	17852	98394	19566	98067	43
18	16160	98686	17880	98389	19595	98061	42
19	16189	98681	17909	98383	19623	98056	41
20	16218	98676	17937	98378	19652	98050	40
21	16246	98671	17966	98373	19680	98044	39
22	16275	98667	17995	98368	19709	98039	38
23	16304	98662	18023	98362	19737	98033	37
24	16333	98657	18052	98357	19766	98027	36
25	16361	98652	18081	98352	19794	98021	35
26	16390	98648	18109	98347	19823	98016	34
27	16419	98643	18138	98341	19851	98010	33
28	16447	98638	18166	98336	19880	98004	32
29	16476	98633	18195	98331	19908	97998	31
30	16505	98629	18224	98325	19937	97992	30
31	16533	98624	18252	98320	19965	97987	29
32	16562	98619	18281	98315	19994	97981	28
33	16591	98614	18309	98310	20022	97975	27
34	16620	98609	18338	98304	20051	97969	26
35	16648	98604	18367	98299	20079	97963	25
36	16677	98600	18395	98294	20108	97958	24
37	16706	98595	18424	98288	20136	97952	23
38	16734	98590	18452	98283	20165	97946	22
39	16763	98585	18481	98277	20193	97940	21
40	16792	98580	18509	98272	20222	97934	20
41	16820	98575	18538	98267	20250	97928	19
42	16849	98570	18567	98261	20279	97922	18
43	16878	98565	18595	98256	20307	97916	17
44	16906	98561	18624	98250	20336	97910	16
45	16935	98556	18652	98245	20364	97905	15
46	16964	98551	18681	98240	20393	97899	14
47	16992	98546	18710	98234	20421	97893	13
48	17021	98541	18738	98229	20450	97887	12
49	17050	98536	18767	98223	20478	97881	11
50	17078	98531	18795	98218	20507	97875	10
51	17107	98526	18824	98212	20535	97869	9
52	17136	98521	18852	98207	20563	97863	8
53	17164	98516	18881	98201	20592	97857	7
54	17193	98511	18910	98196	20620	97851	6
55	17222	98506	18938	98190	20649	97845	5
56	17250	98501	18967	98185	20677	97839	4
57	17279	98496	18995	98179	20706	97833	3
58	17308	98491	19024	98174	20734	97827	2
59	17336	98486	19052	98168	20763	97821	1
60	17365	98481	19081	98163	20791	97815	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	80°		79°		78°		

′	12° N. sin	12° N. cos	13° N. sin	13° N. cos	14° N. sin	14° N. cos	′
0	20791	97815	22495	97437	24192	97030	60
1	20820	97809	22523	97430	24220	97023	59
2	20848	97803	22552	97424	24249	97015	58
3	20877	97797	22580	97417	24277	97008	57
4	20905	97791	22608	97411	24305	97001	56
5	20933	97784	22637	97404	24333	96994	55
6	20962	97778	22665	97398	24362	96987	54
7	20990	97772	22693	97391	24390	96980	53
8	21019	97766	22722	97384	24418	96973	52
9	21047	97760	22750	97378	24446	96966	51
10	21076	97754	22778	97371	24474	96959	50
11	21104	97748	22807	97365	24503	96952	49
12	21132	97742	22835	97358	24531	96945	48
13	21161	97735	22863	97351	24559	96937	47
14	21189	97729	22892	97345	24587	96930	46
15	21218	97723	22920	97338	24615	96923	45
16	21246	97717	22948	97331	24644	96916	44
17	21275	97711	22977	97325	24672	96909	43
18	21303	97705	23005	97318	24700	96902	42
19	21331	97698	23033	97311	24728	96894	41
20	21360	97692	23062	97304	24756	96887	40
21	21388	97686	23090	97298	24784	96880	39
22	21417	97680	23118	97291	24813	96873	38
23	21445	97673	23146	97284	24841	96866	37
24	21474	97667	23175	97278	24869	96858	36
25	21502	97661	23203	97271	24897	96851	35
26	21530	97655	23231	97264	24925	96844	34
27	21559	97648	23260	97257	24953	96837	33
28	21587	97642	23288	97251	24982	96829	32
29	21616	97636	23316	97244	25010	96822	31
30	21644	97630	23345	97237	25038	96815	30
31	21672	97623	23373	97230	25066	96807	29
32	21701	97617	23401	97223	25094	96800	28
33	21729	97611	23429	97217	25122	96793	27
34	21758	97604	23458	97210	25151	96786	26
35	21786	97598	23486	97203	25179	96778	25
36	21814	97592	23514	97196	25207	96771	24
37	21843	97585	23542	97189	25235	96764	23
38	21871	97579	23571	97182	25263	96756	22
39	21899	97573	23599	97176	25291	96749	21
40	21928	97566	23627	97169	25320	96742	20
41	21956	97560	23656	97162	25348	96734	19
42	21985	97553	23684	97155	25376	96727	18
43	22013	97547	23712	97148	25404	96719	17
44	22041	97541	23740	97141	25432	96712	16
45	22070	97534	23769	97134	25460	96705	15
46	22098	97528	23797	97127	25488	96697	14
47	22126	97521	23825	97120	25516	96690	13
48	22155	97515	23853	97113	25545	96682	12
49	22183	97508	23882	97106	25573	96675	11
50	22212	97502	23910	97100	25601	96667	10
51	22240	97496	23938	97093	25629	96660	9
52	22268	97489	23966	97086	25657	96653	8
53	22297	97483	23995	97079	25685	96645	7
54	22325	97476	24023	97072	25713	96638	6
55	22353	97470	24051	97065	25741	96630	5
56	22382	97463	24079	97058	25769	96623	4
57	22410	97457	24108	97051	25798	96615	3
58	22438	97450	24136	97044	25826	96608	2
59	22467	97444	24164	97037	25854	96600	1
60	22495	97437	24192	97030	25882	96593	0
′	77° N. cos	77° N. sin	76° N. cos	76° N. sin	75° N. cos	75° N. sin	′

′	15°		16°		17°		′
	N. sin	N. cos	N. sin	N. cos	N. sin	N. cos	
0	25882	96593	27564	96126	29237	95630	60
1	25910	96585	27592	96118	29265	95622	59
2	25938	96578	27620	96110	29293	95613	58
3	25966	96570	27648	96102	29321	95605	57
4	25994	96562	27676	96094	29348	95596	56
5	26022	96555	27704	96086	29376	95588	55
6	26050	96547	27731	96078	29404	95579	54
7	26079	96540	27759	96070	29432	95571	53
8	26107	96532	27787	96062	29460	95562	52
9	26135	96524	27815	96054	29487	95554	51
10	26163	96517	27843	96046	29515	95545	50
11	26191	96509	27871	96037	29543	95536	49
12	26219	96502	27899	96029	29571	95528	48
13	26247	96494	27927	96021	29599	95519	47
14	26275	96486	27955	96013	29626	95511	46
15	26303	96479	27983	96005	29654	95502	45
16	26331	96471	28011	95997	29682	95493	44
17	26359	96463	28039	95989	29710	95485	43
18	26387	96456	28067	95981	29737	95476	42
19	26415	96448	28095	95972	29765	95467	41
20	26443	96440	28123	95964	29793	95459	40
21	26471	96433	28150	95956	29821	95450	39
22	26500	96425	28178	95948	29849	95441	38
23	26528	96417	28206	95940	29876	95433	37
24	26556	96410	28234	95931	29904	95424	36
25	26584	96402	28262	95923	29932	95415	35
26	26612	96394	28290	95915	29960	95407	34
27	26640	96386	28318	95907	29987	95398	33
28	26668	96379	28346	95898	30015	95389	32
29	26696	96371	28374	95890	30043	95380	31
30	26724	96363	28402	95882	30071	95372	30
31	26752	96355	28429	95874	30098	95363	29
32	26780	96347	28457	95865	30126	95354	28
33	26808	96340	28485	95857	30154	95345	27
34	26836	96332	28513	95849	30182	95337	26
35	26864	96324	28541	95841	30209	95328	25
36	26892	96316	28569	95832	30237	95319	24
37	26920	96308	28597	95824	30265	95310	23
38	26948	96301	28625	95816	30292	95301	22
39	26976	96293	28652	95807	30320	95293	21
40	27004	96285	28680	95799	30348	95284	20
41	27032	96277	28708	95791	30376	95275	19
42	27060	96269	28736	95782	30403	95266	18
43	27088	96261	28764	95774	30431	95257	17
44	27116	96253	28792	95766	30459	95248	16
45	27144	96246	28820	95757	30486	95240	15
46	27172	96238	28847	95749	30514	95231	14
47	27200	96230	28875	95740	30542	95222	13
48	27228	96222	28903	95732	30570	95213	12
49	27256	96214	28931	95724	30597	95204	11
50	27284	96206	28959	95715	30625	95195	10
51	27312	96198	28987	95707	30653	95186	9
52	27340	96190	29015	95698	30680	95177	8
53	27368	96182	29042	95690	30708	95168	7
54	27396	96174	29070	95681	30736	95159	6
55	27424	96166	29098	95673	30763	95150	5
56	27452	96158	29126	95664	30791	95142	4
57	27480	96150	29154	95656	30819	95133	3
58	27508	96142	29182	95647	30846	95124	2
59	27536	96134	29209	95639	30874	95115	1
60	27564	96126	29237	95630	30902	95106	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	74°		73°		72°		

′	18°		19°		20°		′
	N. sin	N. cos	N. sin	N. cos	N. sin	N. cos	
0	30902	95106	32557	94552	34202	93969	60
1	30929	95097	32584	94542	34229	93959	59
2	30957	95088	32612	94533	34257	93949	58
3	30985	95079	32639	94523	34284	93939	57
4	31012	95070	32667	94514	34311	93929	56
5	31040	95061	32694	94504	34339	93919	55
6	31068	95052	32722	94495	34366	93909	54
7	31095	95043	32749	94485	34393	93899	53
8	31123	95033	32777	94476	34421	93889	52
9	31151	95024	32804	94466	34448	93879	51
10	31178	95015	32832	94457	34475	93869	50
11	31206	95006	32859	94447	34503	93859	49
12	31233	94997	32887	94438	34530	93849	48
13	31261	94988	32914	94428	34557	93839	47
14	31289	94979	32942	94418	34584	93829	46
15	31316	94970	32969	94409	34612	93819	45
16	31344	94961	32997	94399	34639	93809	44
17	31372	94952	33024	94390	34666	93799	43
18	31399	94943	33051	94380	34694	93789	42
19	31427	94933	33079	94370	34721	93779	41
20	31454	94924	33106	94361	34748	93769	40
21	31482	94915	33134	94351	34775	93759	39
22	31510	94906	33161	94342	34803	93748	38
23	31537	94897	33189	94332	34830	93738	37
24	31565	94888	33216	94322	34857	93728	36
25	31593	94878	33244	94313	34884	93718	35
26	31620	94869	33271	94303	34912	93708	34
27	31648	94860	33298	94293	34939	93698	33
28	31675	94851	33326	94284	34966	93688	32
29	31703	94842	33353	94274	34993	93677	31
30	31730	94832	33381	94264	35021	93667	30
31	31758	94823	33408	94254	35048	93657	29
32	31786	94814	33436	94245	35075	93647	28
33	31813	94805	33463	94235	35102	93637	27
34	31841	94795	33490	94225	35130	93626	26
35	31868	94786	33518	94216	35157	93616	25
36	31896	94777	33545	94206	35184	93606	24
37	31923	94768	33573	94196	35211	93596	23
38	31951	94758	33600	94186	35239	93585	22
39	31979	94749	33627	94176	35266	93575	21
40	32006	94740	33655	94167	35293	93565	20
41	32034	94730	33682	94157	35320	93555	19
42	32061	94721	33710	94147	35347	93544	18
43	32089	94712	33737	94137	35375	93534	17
44	32116	94702	33764	94127	35402	93524	16
45	32144	94693	33792	94118	35429	93514	15
46	32171	94684	33819	94108	35456	93503	14
47	32199	94674	33846	94098	35484	93493	13
48	32227	94665	33874	94088	35511	93483	12
49	32254	94656	33901	94078	35538	93472	11
50	32282	94646	33929	94068	35565	93462	10
51	32309	94637	33956	94058	35592	93452	9
52	32337	94627	33983	94049	35619	93441	8
53	32364	94618	34011	94039	35647	93431	7
54	32392	94609	34038	94029	35674	93420	6
55	32419	94599	34065	94019	35701	93410	5
56	32447	94590	34093	94009	35728	93400	4
57	32474	94580	34120	93999	35755	93389	3
58	32502	94571	34147	93989	35782	93379	2
59	32529	94561	34175	93979	35810	93368	1
60	32557	94552	34202	93969	35837	93358	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	71°		70°		69°		

′	21°		22°		23°		′
	N. sin	N. cos	N. sin	N. cos	N. sin	N. cos	
0	35837	93358	37461	92718	39073	92050	60
1	35864	93348	37488	92707	39100	92039	59
2	35891	93337	37515	92697	39127	92028	58
3	35918	93327	37542	92686	39153	92016	57
4	35945	93316	37569	92675	39180	92005	56
5	35973	93306	37595	92664	39207	91994	55
6	36000	93295	37622	92653	39234	91982	54
7	36027	93285	37649	92642	39260	91971	53
8	36054	93274	37676	92631	39287	91959	52
9	36081	93264	37703	92620	39314	91948	51
10	36108	93253	37730	92609	39341	91936	50
11	36135	93243	37757	92598	39367	91925	49
12	36162	93232	37784	92587	39394	91914	48
13	36190	93222	37811	92576	39421	91902	47
14	36217	93211	37838	92565	39448	91891	46
15	36244	93201	37865	92554	39474	91879	45
16	36271	93190	37892	92543	39501	91868	44
17	36298	93180	37919	92532	39528	91856	43
18	36325	93169	37946	92521	39555	91845	42
19	36352	93159	37973	92510	39581	91833	41
20	36379	93148	37999	92499	39608	91822	40
21	36406	93137	38026	92488	39635	91810	39
22	36434	93127	38053	92477	39661	91799	38
23	36461	93116	38080	92466	39688	91787	37
24	36488	93106	38107	92455	39715	91775	36
25	36515	93095	38134	92444	39741	91764	35
26	36542	93084	38161	92432	39768	91752	34
27	36569	93074	38188	92421	39795	91741	33
28	36596	93063	38215	92410	39822	91729	32
29	36623	93052	38241	92399	39848	91718	31
30	36650	93042	38268	92388	39875	91706	30
31	36677	93031	38295	92377	39902	91694	29
32	36704	93020	38322	92366	39928	91683	28
33	36731	93010	38349	92355	39955	91671	27
34	36758	92999	38376	92343	39982	91660	26
35	36785	92988	38403	92332	40008	91648	25
36	36812	92978	38430	92321	40035	91636	24
37	36839	92967	38456	92310	40062	91625	23
38	36867	92956	38483	92299	40088	91613	22
39	36894	92945	38510	92287	40115	91601	21
40	36921	92935	38537	92276	40141	91590	20
41	36948	92924	38564	92265	40168	91578	19
42	36975	92913	38591	92254	40195	91566	18
43	37002	92902	38617	92243	40221	91555	17
44	37029	92892	38644	92231	40248	91543	16
45	37056	92881	38671	92220	40275	91531	15
46	37083	92870	38698	92209	40301	91519	14
47	37110	92859	38725	92198	40328	91508	13
48	37137	92849	38752	92186	40355	91496	12
49	37164	92838	38778	92175	40381	91484	11
50	37191	92827	38805	92164	40408	91472	10
51	37218	92816	38832	92152	40434	91461	9
52	37245	92805	38859	92141	40461	91449	8
53	37272	92794	38886	92130	40488	91437	7
54	37299	92784	38912	92119	40514	91425	6
55	37326	92773	38939	92107	40541	91414	5
56	37353	92762	38966	92096	40567	91402	4
57	37380	92751	38993	92085	40594	91390	3
58	37407	92740	39020	92073	40621	91378	2
59	37434	92729	39046	92062	40647	91366	1
60	37461	92718	39073	92050	40674	91355	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	68°		67°		66°		

′	24°		25°		26°		′
	N. sin	N. cos	N. sin	N. cos	N. sin	N. cos	
0	40674	91355	42262	90631	43837	89879	60
1	40700	91343	42288	90618	43863	89867	59
2	40727	91331	42315	90606	43889	89854	58
3	40753	91319	42341	90594	43916	89841	57
4	40780	91307	42367	90582	43942	89828	56
5	40806	91295	42394	90569	43968	89816	55
6	40833	91283	42420	90557	43994	89803	54
7	40860	91272	42446	90545	44020	89790	53
8	40886	91260	42473	90532	44046	89777	52
9	40913	91248	42499	90520	44072	89764	51
10	40939	91236	42525	90507	44098	89752	50
11	40966	91224	42552	90495	44124	89739	49
12	40992	91212	42578	90483	44151	89726	48
13	41019	91200	42604	90470	44177	89713	47
14	41045	91188	42631	90458	44203	89700	46
15	41072	91176	42657	90446	44229	89687	45
16	41098	91164	42683	90433	44255	89674	44
17	41125	91152	42709	90421	44281	89662	43
18	41151	91140	42736	90408	44307	89649	42
19	41178	91128	42762	90396	44333	89636	41
20	41204	91116	42788	90383	44359	89623	40
21	41231	91104	42815	90371	44385	89610	39
22	41257	91092	42841	90358	44411	89597	38
23	41284	91080	42867	90346	44437	89584	37
24	41310	91068	42894	90334	44464	89571	36
25	41337	91056	42920	90321	44490	89558	35
26	41363	91044	42946	90309	44516	89545	34
27	41390	91032	42972	90296	44542	89532	33
28	41416	91020	42999	90284	44568	89519	32
29	41443	91008	43025	90271	44594	89506	31
30	41469	90996	43051	90259	44620	89493	30
31	41496	90984	43077	90246	44646	89480	29
32	41522	90972	43104	90233	44672	89467	28
33	41549	90960	43130	90221	44698	89454	27
34	41575	90948	43156	90208	44724	89441	26
35	41602	90936	43182	90196	44750	89428	25
36	41628	90924	43209	90183	44776	89415	24
37	41655	90911	43235	90171	44802	89402	23
38	41681	90899	43261	90158	44828	89389	22
39	41707	90887	43287	90146	44854	89376	21
40	41734	90875	43313	90133	44880	89363	20
41	41760	90863	43340	90120	44906	89350	19
42	41787	90851	43366	90108	44932	89337	18
43	41813	90839	43392	90095	44958	89324	17
44	41840	90826	43418	90082	44984	89311	16
45	41866	90814	43445	90070	45010	89298	15
46	41892	90802	43471	90057	45036	89285	14
47	41919	90790	43497	90045	45062	89272	13
48	41945	90778	43523	90032	45088	89259	12
49	41972	90766	43549	90019	45114	89245	11
50	41998	90753	43575	90007	45140	89232	10
51	42024	90741	43602	89994	45166	89219	9
52	42051	90729	43628	89981	45192	89206	8
53	42077	90717	43654	89968	45218	89193	7
54	42104	90704	43680	89956	45243	89180	6
55	42130	90692	43706	89943	45269	89167	5
56	42156	90680	43733	89930	45295	89153	4
57	42183	90668	43759	89918	45321	89140	3
58	42209	90655	43785	89905	45347	89127	2
59	42235	90643	43811	89892	45373	89114	1
60	42262	90631	43837	89879	45399	89101	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	65°		64°		63°		

′	27°		28°		29°		′
	N. sin	N. cos	N. sin	N. cos	N. sin	N. cos	
0	45399	89101	46947	88295	48481	87462	60
1	45425	89087	46973	88281	48506	87448	59
2	45451	89074	46999	88267	48532	87434	58
3	45477	89061	47024	88254	48557	87420	57
4	45503	89048	47050	88240	48583	87406	56
5	45529	89035	47076	88226	48608	87391	55
6	45554	89021	47101	88213	48634	87377	54
7	45580	89008	47127	88199	48659	87363	53
8	45606	88995	47153	88185	48684	87349	52
9	45632	88981	47178	88172	48710	87335	51
10	45658	88968	47204	88158	48735	87321	50
11	45684	88955	47229	88144	48761	87306	49
12	45710	88942	47255	88130	48786	87292	48
13	45736	88928	47281	88117	48811	87278	47
14	45762	88915	47306	88103	48837	87264	46
15	45787	88902	47332	88089	48862	87250	45
16	45813	88888	47358	88075	48888	87235	44
17	45839	88875	47383	88062	48913	87221	43
18	45865	88862	47409	88048	48938	87207	42
19	45891	88848	47434	88034	48964	87193	41
20	45917	88835	47460	88020	48989	87178	40
21	45942	88822	47486	88006	49014	87164	39
22	45968	88808	47511	87993	49040	87150	38
23	45994	88795	47537	87979	49065	87136	37
24	46020	88782	47562	87965	49090	87121	36
25	46046	88768	47588	87951	49116	87107	35
26	46072	88755	47614	87937	49141	87093	34
27	46097	88741	47639	87923	49166	87079	33
28	46123	88728	47665	87909	49192	87064	32
29	46149	88715	47690	87896	49217	87050	31
30	46175	88701	47716	87882	49242	87036	30
31	46201	88688	47741	87868	49268	87021	29
32	46226	88674	47767	87854	49293	87007	28
33	46252	88661	47793	87840	49318	86993	27
34	46278	88647	47818	87826	49344	86978	26
35	46304	88634	47844	87812	49369	86964	25
36	46330	88620	47869	87798	49394	86949	24
37	46355	88607	47895	87784	49419	86935	23
38	46381	88593	47920	87770	49445	86921	22
39	46407	88580	47946	87756	49470	86906	21
40	46433	88566	47971	87743	49495	86892	20
41	46458	88553	47997	87729	49521	86878	19
42	46484	88539	48022	87715	49546	86863	18
43	46510	88526	48048	87701	49571	86849	17
44	46536	88512	48073	87687	49596	86834	16
45	46561	88499	48099	87673	49622	86820	15
46	46587	88485	48124	87659	49647	86805	14
47	46613	88472	48150	87645	49672	86791	13
48	46639	88458	48175	87631	49697	86777	12
49	46664	88445	48201	87617	49723	86762	11
50	46690	88431	48226	87603	49748	86748	10
51	46716	88417	48252	87589	49773	86733	9
52	46742	88404	48277	87575	49798	86719	8
53	46767	88390	48303	87561	49824	86704	7
54	46793	88377	48328	87546	49849	86690	6
55	46819	88363	48354	87532	49874	86675	5
56	46844	88349	48379	87518	49899	86661	4
57	46870	88336	48405	87504	49924	86646	3
58	46896	88322	48430	87490	49950	86632	2
59	46921	88308	48456	87476	49975	86617	1
60	46947	88295	48481	87462	50000	86603	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	62°		61°		60°		

	30°		31°		32°		
′	N. sin	N. cos	N. sin	N. cos	N. sin	N. cos	′
0	50000	86603	51504	85717	52992	84805	60
1	50025	86588	51529	85702	53017	84789	59
2	50050	86573	51554	85687	53041	84774	58
3	50076	86559	51579	85672	53066	84759	57
4	50101	86544	51604	85657	53091	84743	56
5	50126	86530	51628	85642	53115	84728	55
6	50151	86515	51653	85627	53140	84712	54
7	50176	86501	51678	85612	53164	84697	53
8	50201	86486	51703	85597	53189	84681	52
9	50227	86471	51728	85582	53214	84666	51
10	50252	86457	51753	85567	53238	84650	50
11	50277	86442	51778	85551	53263	84635	49
12	50302	86427	51803	85536	53288	84619	48
13	50327	86413	51828	85521	53312	84604	47
14	50352	86398	51852	85506	53337	84588	46
15	50377	86384	51877	85491	53361	84573	45
16	50403	86369	51902	85476	53386	84557	44
17	50428	86354	51927	85461	53411	84542	43
18	50453	86340	51952	85446	53435	84526	42
19	50478	86325	51977	85431	53460	84511	41
20	50503	86310	52002	85416	53484	84495	40
21	50528	86295	52026	85401	53509	84480	39
22	50553	86281	52051	85385	53534	84464	38
23	50578	86266	52076	85370	53558	84448	37
24	50603	86251	52101	85355	53583	84433	36
25	50628	86237	52126	85340	53607	84417	35
26	50654	86222	52151	85325	53632	84402	34
27	50679	86207	52175	85310	53656	84386	33
28	50704	86192	52200	85294	53681	84370	32
29	50729	86178	52225	85279	53705	84355	31
30	50754	86163	52250	85264	53730	84339	30
31	50779	86148	52275	85249	53754	84324	29
32	50804	86133	52299	85234	53779	84308	28
33	50829	86119	52324	85218	53804	84292	27
34	50854	86104	52349	85203	53828	84277	26
35	50879	86089	52374	85188	53853	84261	25
36	50904	86074	52399	85173	53877	84245	24
37	50929	86059	52423	85157	53902	84230	23
38	50954	86045	52448	85142	53926	84214	22
39	50979	86030	52473	85127	53951	84198	21
40	51004	86015	52498	85112	53975	84182	20
41	51029	86000	52522	85096	54000	84167	19
42	51054	85985	52547	85081	54024	84151	18
43	51079	85970	52572	85066	54049	84135	17
44	51104	85956	52597	85051	54073	84120	16
45	51129	85941	52621	85035	54097	84104	15
46	51154	85926	52646	85020	54122	84088	14
47	51179	85911	52671	85005	54146	84072	13
48	51204	85896	52696	84989	54171	84057	12
49	51229	85881	52720	84974	54195	84041	11
50	51254	85866	52745	84959	54220	84025	10
51	51279	85851	52770	84943	54244	84009	9
52	51304	85836	52794	84928	54269	83994	8
53	51329	85821	52819	84913	54293	83978	7
54	51354	85806	52844	84897	54317	83962	6
55	51379	85792	52869	84882	54342	83946	5
56	51404	85777	52893	84866	54366	83930	4
57	51429	85762	52918	84851	54391	83915	3
58	51454	85747	52943	84836	54415	83899	2
59	51479	85732	52967	84820	54440	83883	1
60	51504	85717	52992	84805	54464	83867	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	59°		58°		57°		

	33°		34°		35°		
′	N. sin	N. cos	N. sin	N. cos	N. sin	N. cos	′
0	54464	83867	55919	82904	57358	81915	60
1	54488	83851	55943	82887	57381	81899	59
2	54513	83835	55968	82871	57405	81882	58
3	54537	83819	55992	82855	57429	81865	57
4	54561	83804	56016	82839	57453	81848	56
5	54586	83788	56040	82822	57477	81832	55
6	54610	83772	56064	82806	57501	81815	54
7	54635	83756	56088	82790	57524	81798	53
8	54659	83740	56112	82773	57548	81782	52
9	54683	83724	56136	82757	57572	81765	51
10	54708	83708	56160	82741	57596	81748	50
11	54732	83692	56184	82724	57619	81731	49
12	54756	83676	56208	82708	57643	81714	48
13	54781	83660	56232	82692	57667	81698	47
14	54805	83645	56256	82675	57691	81681	46
15	54829	83629	56280	82659	57715	81664	45
16	54854	83613	56305	82643	57738	81647	44
17	54878	83597	56329	82626	57762	81631	43
18	54902	83581	56353	82610	57786	81614	42
19	54927	83565	56377	82593	57810	81597	41
20	54951	83549	56401	82577	57833	81580	40
21	54975	83533	56425	82561	57857	81563	39
22	54999	83517	56449	82544	57881	81546	38
23	55024	83501	56473	82528	57904	81530	37
24	55048	83485	56497	82511	57928	81513	36
25	55072	83469	56521	82495	57952	81496	35
26	55097	83453	56545	82478	57976	81479	34
27	55121	83437	56569	82462	57999	81462	33
28	55145	83421	56593	82446	58023	81445	32
29	55169	83405	56617	82429	58047	81428	31
30	55194	83389	56641	82413	58070	81412	30
31	55218	83373	56665	82396	58094	81395	29
32	55242	83356	56689	82380	58118	81378	28
33	55266	83340	56713	82363	58141	81361	27
34	55291	83324	56736	82347	58165	81344	26
35	55315	83308	56760	82330	58189	81327	25
36	55339	83292	56784	82314	58212	81310	24
37	55363	83276	56808	82297	58236	81293	23
38	55388	83260	56832	82281	58260	81276	22
39	55412	83244	56856	82264	58283	81259	21
40	55436	83228	56880	82248	58307	81242	20
41	55460	83212	56904	82231	58330	81225	19
42	55484	83195	56928	82214	58354	81208	18
43	55509	83179	56952	82198	58378	81191	17
44	55533	83163	56976	82181	58401	81174	16
45	55557	83147	57000	82165	58425	81157	15
46	55581	83131	57024	82148	58449	81140	14
47	55605	83115	57047	82132	58472	81123	13
48	55630	83098	57071	82115	58496	81106	12
49	55654	83082	57095	82098	58519	81089	11
50	55678	83066	57119	82082	58543	81072	10
51	55702	83050	57143	82065	58567	81055	9
52	55726	83034	57167	82048	58590	81038	8
53	55750	83017	57191	82032	58614	81021	7
54	55775	83001	57215	82015	58637	81004	6
55	55799	82985	57238	81999	58661	80987	5
56	55823	82969	57262	81982	58684	80970	4
57	55847	82953	57286	81965	58708	80953	3
58	55871	82936	57310	81949	58731	80936	2
59	55895	82920	57334	81932	58755	80919	1
60	55919	82904	57358	81915	58779	80902	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	56°		55°		54°		

′	36° N. sin	36° N. cos	37° N. sin	37° N. cos	38° N. sin	38° N. cos	
0	58779	80902	60182	79864	61566	78801	60
1	58802	80885	60205	79846	61589	78783	59
2	58826	80867	60228	79829	61612	78765	58
3	58849	80850	60251	79811	61635	78747	57
4	58873	80833	60274	79793	61658	78729	56
5	58896	80816	60298	79776	61681	78711	55
6	58920	80799	60321	79758	61704	78694	54
7	58943	80782	60344	79741	61726	78676	53
8	58967	80765	60367	79723	61749	78658	52
9	58990	80748	60390	79706	61772	78640	51
10	59014	80730	60414	79688	61795	78622	50
11	59037	80713	60437	79671	61818	78604	49
12	59061	80696	60460	79653	61841	78586	48
13	59084	80679	60483	79635	61864	78568	47
14	59108	80662	60506	79618	61887	78550	46
15	59131	80644	60529	79600	61909	78532	45
16	59154	80627	60553	79583	61932	78514	44
17	59178	80610	60576	79565	61955	78496	43
18	59201	80593	60599	79547	61978	78478	42
19	59225	80576	60622	79530	62001	78460	41
20	59248	80558	60645	79512	62024	78442	40
21	59272	80541	60668	79494	62046	78424	39
22	59295	80524	60691	79477	62069	78405	38
23	59318	80507	60714	79459	62092	78387	37
24	59342	80489	60738	79441	62115	78369	36
25	59365	80472	60761	79424	62138	78351	35
26	59389	80455	60784	79406	62160	78333	34
27	59412	80438	60807	79388	62183	78315	33
28	59436	80420	60830	79371	62206	78297	32
29	59459	80403	60853	79353	62229	78279	31
30	59482	80386	60876	79335	62251	78261	30
31	59506	80368	60899	79318	62274	78243	29
32	59529	80351	60922	79300	62297	78225	28
33	59552	80334	60945	79282	62320	78206	27
34	59576	80316	60968	79264	62342	78188	26
35	59599	80299	60991	79247	62365	78170	25
36	59622	80282	61015	79229	62388	78152	24
37	59646	80264	61038	79211	62411	78134	23
38	59669	80247	61061	79193	62433	78116	22
39	59693	80230	61084	79176	62456	78098	21
40	59716	80212	61107	79158	62479	78079	20
41	59739	80195	61130	79140	62502	78061	19
42	59763	80178	61153	79122	62524	78043	18
43	59786	80160	61176	79105	62547	78025	17
44	59809	80143	61199	79087	62570	78007	16
45	59832	80125	61222	79069	62592	77988	15
46	59856	80108	61245	79051	62615	77970	14
47	59879	80091	61268	79033	62638	77952	13
48	59902	80073	61291	79016	62660	77934	12
49	59926	80056	61314	78998	62683	77916	11
50	59949	80038	61337	78980	62706	77897	10
51	59972	80021	61360	78962	62728	77879	9
52	59995	80003	61383	78944	62751	77861	8
53	60019	79986	61406	78926	62774	77843	7
54	60042	79968	61429	78908	62796	77824	6
55	60065	79951	61451	78891	62819	77806	5
56	60089	79934	61474	78873	62842	77788	4
57	60112	79916	61497	78855	62864	77769	3
58	60135	79899	61520	78837	62887	77751	2
59	60158	79881	61543	78819	62909	77733	1
60	60182	79864	61566	78801	62932	77715	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	53°		52°		51°		

′	39°		40°		41°		′
	N. sin	N. cos	N. sin	N. cos	N. sin	N. cos	
0	62932	77715	64279	76604	65606	75471	60
1	62955	77696	64301	76586	65628	75452	59
2	62977	77678	64323	76567	65650	75433	58
3	63000	77660	64346	76548	65672	75414	57
4	63022	77641	64368	76530	65694	75395	56
5	63045	77623	64390	76511	65716	75375	55
6	63068	77605	64412	76492	65738	75356	54
7	63090	77586	64435	76473	65759	75337	53
8	63113	77568	64457	76455	65781	75318	52
9	63135	77550	64479	76436	65803	75299	51
10	63158	77531	64501	76417	65825	75280	50
11	63180	77513	64524	76398	65847	75261	49
12	63203	77494	64546	76380	65869	75241	48
13	63225	77476	64568	76361	65891	75222	47
14	63248	77458	64590	76342	65913	75203	46
15	63271	77439	64612	76323	65935	75184	45
16	63293	77421	64635	76304	65956	75165	44
17	63316	77402	64657	76286	65978	75146	43
18	63338	77384	64679	76267	66000	75126	42
19	63361	77366	64701	76248	66022	75107	41
20	63383	77347	64723	76229	66044	75088	40
21	63406	77329	64746	76210	66066	75069	39
22	63428	77310	64768	76192	66088	75050	38
23	63451	77292	64790	76173	66109	75030	37
24	63473	77273	64812	76154	66131	75011	36
25	63496	77255	64834	76135	66153	74992	35
26	63518	77236	64856	76116	66175	74973	34
27	63540	77218	64878	76097	66197	74953	33
28	63563	77199	64901	76078	66218	74934	32
29	63585	77181	64923	76059	66240	74915	31
30	63608	77162	64945	76041	66262	74896	30
31	63630	77144	64967	76022	66284	74876	29
32	63653	77125	64989	76003	66306	74857	28
33	63675	77107	65011	75984	66327	74838	27
34	63698	77088	65033	75965	66349	74818	26
35	63720	77070	65055	75946	66371	74799	25
36	63742	77051	65077	75927	66393	74780	24
37	63765	77033	65100	75908	66414	74760	23
38	63787	77014	65122	75889	66436	74741	22
39	63810	76996	65144	75870	66458	74722	21
40	63832	76977	65166	75851	66480	74703	20
41	63854	76959	65188	75832	66501	74683	19
42	63877	76940	65210	75813	66523	74664	18
43	63899	76921	65232	75794	66545	74644	17
44	63922	76903	65254	75775	66566	74625	16
45	63944	76884	65276	75756	66588	74606	15
46	63966	76866	65298	75738	66610	74586	14
47	63989	76847	65320	75719	66632	74567	13
48	64011	76828	65342	75700	66653	74548	12
49	64033	76810	65364	75680	66675	74528	11
50	64056	76791	65386	75661	66697	74509	10
51	64078	76772	65408	75642	66718	74489	9
52	64100	76754	65430	75623	66740	74470	8
53	64123	76735	65452	75604	66762	74451	7
54	64145	76717	65474	75585	66783	74431	6
55	64167	76698	65496	75566	66805	74412	5
56	64190	76679	65518	75547	66827	74392	4
57	64212	76661	65540	75528	66848	74373	3
58	64234	76642	65562	75509	66870	74353	2
59	64256	76623	65584	75490	66891	74334	1
60	64279	76604	65606	75471	66913	74314	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	50°		49°		48°		

′	42° N. sin	42° N. cos	43° N. sin	43° N. cos	44° N. sin	44° N. cos	′
0	66913	74314	68200	73135	69466	71934	60
1	66935	74295	68221	73116	69487	71914	59
2	66956	74276	68242	73096	69508	71894	58
3	66978	74256	68264	73076	69529	71873	57
4	66999	74237	68285	73056	69549	71853	56
5	67021	74217	68306	73036	69570	71833	55
6	67043	74198	68327	73016	69591	71813	54
7	67064	74178	68349	72996	69612	71792	53
8	67086	74159	68370	72976	69633	71772	52
9	67107	74139	68391	72957	69654	71752	51
10	67129	74120	68412	72937	69675	71732	50
11	67151	74100	68434	72917	69696	71711	49
12	67172	74080	68455	72897	69717	71691	48
13	67194	74061	68476	72877	69737	71671	47
14	67215	74041	68497	72857	69758	71650	46
15	67237	74022	68518	72837	69779	71630	45
16	67258	74002	68539	72817	69800	71610	44
17	67280	73983	68561	72797	69821	71590	43
18	67301	73963	68582	72777	69842	71569	42
19	67323	73944	68603	72757	69862	71549	41
20	67344	73924	68624	72737	69883	71529	40
21	67366	73904	68645	72717	69904	71508	39
22	67387	73885	68666	72697	69925	71488	38
23	67409	73865	68688	72677	69946	71468	37
24	67430	73846	68709	72657	69966	71447	36
25	67452	73826	68730	72637	69987	71427	35
26	67473	73806	68751	72617	70008	71407	34
27	67495	73787	68772	72597	70029	71386	33
28	67516	73767	68793	72577	70049	71366	32
29	67538	73747	68814	72557	70070	71345	31
30	67559	73728	68835	72537	70091	71325	30
31	67580	73708	68857	72517	70112	71305	29
32	67602	73688	68878	72497	70132	71284	28
33	67623	73669	68899	72477	70153	71264	27
34	67645	73649	68920	72457	70174	71243	26
35	67666	73629	68941	72437	70195	71223	25
36	67688	73610	68962	72417	70215	71203	24
37	67709	73590	68983	72397	70236	71182	23
38	67730	73570	69004	72377	70257	71162	22
39	67752	73551	69025	72357	70277	71141	21
40	67773	73531	69046	72337	70298	71121	20
41	67795	73511	69067	72317	70319	71100	19
42	67816	73491	69088	72297	70339	71080	18
43	67837	73472	69109	72277	70360	71059	17
44	67859	73452	69130	72257	70381	71039	16
45	67880	73432	69151	72236	70401	71019	15
46	67901	73413	69172	72216	70422	70998	14
47	67923	73393	69193	72196	70443	70978	13
48	67944	73373	69214	72176	70463	70957	12
49	67965	73353	69235	72156	70484	70937	11
50	67987	73333	69256	72136	70505	70916	10
51	68008	73314	69277	72116	70525	70896	9
52	68029	73294	69298	72095	70546	70875	8
53	68051	73274	69319	72075	70567	70855	7
54	68072	73254	69340	72055	70587	70834	6
55	68093	73234	69361	72035	70608	70813	5
56	68115	73215	69382	72015	70628	70793	4
57	68136	73195	69403	71995	70649	70772	3
58	68157	73175	69424	71974	70670	70752	2
59	68179	73155	69445	71954	70690	70731	1
60	68200	73135	69466	71934	70711	70711	0
′	N. cos	N. sin	N. cos	N. sin	N. cos	N. sin	′
	47°		46°		45°		

Links.	Feet.	Links.	Feet.	Links.	Feet.	Links.	Feet.
1	·66	61	40·26	121	79·86	181	119·46
2	1·32	62	40·92	122	80·52	182	120·12
3	1·98	63	41·58	123	81·18	183	120·78
4	2·64	64	42·24	124	81·84	184	121·44
5	**3·30**	**65**	**42·90**	**125**	**82·50**	**185**	**122·10**
6	3·96	66	43·56	126	83·16	186	122·76
7	4·62	67	44·22	127	83·82	187	123·42
8	5·28	68	44·88	128	84·48	188	124·08
9	5·94	69	45·54	129	85·14	189	124·74
10	**6·60**	**70**	**46·20**	**130**	**85·80**	**190**	**125·40**
11	7·26	71	46·86	131	86·46	191	126·06
12	7·92	72	47·52	132	87·12	192	126·72
13	8·58	73	48·18	133	87·78	193	127·38
14	9·24	74	48·84	134	88·44	194	128·04
15	**9·90**	**75**	**49·50**	**135**	**89·10**	**195**	**128·70**
16	10·56	76	50·16	136	89·76	196	129·36
17	11·22	77	50·82	137	90·42	197	130·02
18	11·88	78	51·48	138	91·08	198	130·68
19	12·54	79	52·14	139	91·74	199	131·34
20	**13·20**	**80**	**52·80**	**140**	**92·40**	**200**	**132·00**
21	13·86	81	53·46	141	93·06	201	132·66
22	14·52	82	54·12	142	93·72	202	133·32
23	15·18	83	54·78	143	94.38	203	133·98
24	15·84	84	55·44	144	95·04	204	134·64
25	**16·50**	**85**	**56·10**	**145**	**95·70**	**205**	**135·30**
26	17·16	86	56·76	146	96·36	206	135·96
27	17·82	87	57·42	147	97·02	207	136·62
28	18·48	88	58·08	148	97·68	208	137·28
29	19·14	89	58·74	149	98·34	209	137·94
30	**19·80**	**90**	**59·40**	**150**	**99·00**	**210**	**138·60**
31	20·46	91	60·06	151	99·66	211	139.26
32	21·12	92	60·72	152	100·32	212	139·92
33	21·78	93	61·38	153	100·98	213	140·58
34	22·44	94	62·04	154	101·64	214	141·24
35	**23·10**	**95**	**62·70**	**155**	**102·30**	**215**	**141·90**
36	23·76	96	63·36	156	102·96	216	142·56
37	24·42	97	64·02	157	103·62	217	143·22
38	25·08	98	64·68	158	104·28	218	143·88
39	25·74	99	65·34	159	104·94	219	144·54
40	**26·40**	**100**	**66·00**	**160**	**105·60**	**220**	**145·20**
41	27·06	101	66·66	161	106·26	221	145·86
42	27·72	102	67·32	162	106·92	222	146·52
43	28·38	103	67·98	163	107·58	223	147·18
44	29·04	104	68·64	164	108·24	224	147.84
45	**29·70**	**105**	**69.30**	**165**	**108·90**	**225**	**148·50**
46	30·36	106	69·96	166	109·56	226	149·16
47	31·02	107	70·62	167	110·22	227	149·82
48	31·68	108	71·28	168	110·88	228	150·48
49	32·34	109	71·94	169	111·54	229	151·14
50	**33·00**	**110**	**72·60**	**170**	**112·20**	**230**	**151·80**
51	33·66	111	73·26	171	112·86	231	152·46
52	34·32	112	73·92	172	113·52	232	153.12
53	34·98	113	74·58	173	114·18	233	153·78
54	35·64	114	75·24	174	114·84	234	154·44
55	**36·30**	**115**	**75·90**	**175**	**115·50**	**235**	**155·10**
56	36·96	116	76·56	176	116·16	236	155·76
57	37·62	117	77·22	177	116·82	237	156·42
58	38·28	118	77·88	178	117·48	238	157·08
59	38·94	119	78·54	179	118·14	239	157·74
60	**39·60**	**120**	**79·20**	**180**	**118·80**	**240**	**158·40**

Links.	Feet.	Links.	Feet.	Links.	Feet.	Links.	Feet.
241	159·06	301	198·66	361	238·26	421	277·86
242	159·72	302	199·32	362	238·92	422	278·52
243	160·38	303	199·98	363	239·58	423	279·18
244	161·04	304	200·64	364	240·24	424	279·84
245	**161·70**	**305**	**201·30**	**365**	**240·90**	**425**	**280·50**
246	162·36	306	201·96	366	241·56	426	281·16
247	163·02	307	202·62	367	242·22	427	281·82
248	163·68	308	203·28	368	242·88	428	282·48
249	164·34	309	203·94	369	243·54	429	283·14
250	**165·00**	**310**	**204·60**	**370**	**244·20**	**430**	**283·80**
251	165·66	311	205·26	371	244·86	431	284·46
252	166·32	312	205·92	372	245·52	432	285·12
253	166·98	313	206·58	373	246·18	433	285·78
254	167·64	314	207·24	374	246·84	434	286·44
255	**168·30**	**315**	**207·90**	**375**	**247·50**	**435**	**287·10**
256	168·96	316	208·56	376	248·16	436	287·76
257	169·62	317	209·22	377	248·82	437	288·42
258	170·28	318	209·88	378	249·48	438	289·08
259	170·94	319	210·54	379	250·14	439	289·74
260	**171·60**	**320**	**211·20**	**380**	**250·80**	**440**	**290·40**
261	172·26	321	211·86	381	251·46	441	291·06
262	172·92	322	212·54	382	252·12	442	291·72
263	173·58	323	213·18	383	252·78	443	292·38
264	174·24	324	213·84	384	253·44	444	293·04
265	**174·90**	**325**	**214·50**	**385**	**254·10**	**445**	**293·70**
266	175·56	326	215·16	386	254·76	446	294·36
267	176·22	327	215·82	387	255·42	447	295·02
268	176·88	328	216·48	388	256·08	448	295·68
269	177·54	329	217·14	389	256·74	449	296·34
270	**178·20**	**330**	**217·80**	**390**	**257·40**	**450**	**297·00**
271	178·86	331	218·46	391	258·06	451	297·66
272	179·52	332	219·12	392	258·72	452	298·32
273	180·18	333	219·78	393	259·38	453	298·98
274	180·84	334	220·44	394	260·04	454	299·64
275	**181·50**	**335**	**221·10**	**395**	**260·70**	**455**	**300·30**
276	182·16	336	221·76	396	261·36	456	300·96
277	182·82	337	222·42	397	262·02	457	301·62
278	183·48	338	223·08	398	262·68	458	302·28
279	184·14	339	223·74	399	263·34	459	302·94
280	**184·80**	**340**	**224·40**	**400**	**264·00**	**460**	**303·60**
281	185·46	341	225·06	401	264·66	461	304·26
282	186·12	342	225·72	402	265·32	462	304·92
283	186·78	343	226·38	403	265·98	463	305·58
284	187·44	344	227·04	404	266·64	464	306·24
285	**188·10**	**345**	**227·70**	**405**	**267·30**	**465**	**306·90**
286	188·76	346	228·36	406	267·96	466	307·56
287	189·42	347	229·02	407	268·62	467	308·22
288	190·08	348	229·68	408	269·28	468	308·88
289	190·74	349	230·34	409	269·94	469	309·54
290	**191·40**	**350**	**231·00**	**410**	**270·60**	**470**	**310·20**
291	192·06	351	231·66	411	271·26	471	310·86
292	192·72	352	232·32	412	271·92	472	311·52
293	193·38	353	232·98	413	272·58	473	312·18
294	194·04	354	233·64	414	273·24	474	312·84
295	**194·70**	**355**	**234·30**	**415**	**273·90**	**475**	**313·50**
296	195·36	356	234·96	416	274·56	476	314·16
297	196·02	357	235·62	417	275·22	477	314·82
298	196·68	358	236·28	418	275·88	478	315·48
299	197·34	359	236·94	419	276·54	479	316·14
300	**198·00**	**360**	**237·60**	**420**	**277·20**	**480**	**316·80**

Links.	Feet.	Links.	Feet.	Links.	Feet.	Links.	Feet.
481	317·46	541	357·06	601	396·66	661	436·26
482	318·12	542	357·72	602	397·32	662	436·92
483	318·78	543	358·38	603	397·98	663	437·58
484	319·44	544	359·04	604	398·64	664	438·24
485	**320·10**	**545**	**359·70**	**605**	**399·30**	**665**	**438·90**
486	320·76	546	360·36	606	399·96	666	439·56
487	321·42	547	361·02	607	400·62	667	440·22
488	322·08	548	361·68	608	401·28	668	440·88
489	322·74	549	362·34	609	401·94	669	441·54
490	**323·40**	**550**	**363·00**	**610**	**402·60**	**670**	**442·20**
491	324·06	551	363·66	611	403·26	671	442·86
492	324·72	552	364·32	612	403·92	672	443·52
493	325·38	553	364·98	613	404·58	673	444·18
494	326·04	554	365·64	614	405·24	674	444·84
495	**326·70**	**555**	**366·30**	**615**	**405·90**	**675**	**445·50**
496	327·36	556	366·96	616	406·56	676	446·16
497	328·02	557	367·62	617	407·22	677	446·82
498	328·68	558	368·28	618	407·88	678	447·48
499	329·34	559	368·94	619	408·54	679	448·14
500	**330·00**	**560**	**369·60**	**620**	**409·20**	**680**	**448·80**
501	330·66	561	370·26	621	409·86	681	449·46
502	331·32	562	370·92	622	410·52	682	450·12
503	331·98	563	371·58	623	411·18	683	450·78
504	332·64	564	372·24	624	411·84	684	451·44
505	**333·30**	**565**	**372·90**	**625**	**412·50**	**685**	**452·10**
506	333·96	566	373·56	626	413·16	686	452·76
507	334·62	567	374·22	627	413·82	687	453·42
508	335·28	568	374·88	628	414·48	688	454·08
509	335·94	569	375·54	629	415·14	689	454·74
510	**336·60**	**570**	**376·20**	**630**	**415·80**	**690**	**455·40**
511	337·26	571	376·86	631	416·46	691	456·06
512	337·92	572	377·52	632	417·12	692	456·72
513	338·58	573	378·18	633	417·78	693	457·38
514	339·24	574	378·84	634	418·44	694	458·04
515	**339·90**	**575**	**379·50**	**635**	**419·10**	**695**	**458·70**
516	340·56	576	380·16	636	419·76	696	459·36
517	341·22	577	380·82	637	420·42	697	460·02
518	341·88	578	381·48	638	421·08	698	460·68
519	342·54	579	382·14	639	421·74	699	461·34
520	**343·20**	**580**	**382·80**	**640**	**422·40**	**700**	**462·00**
521	343·86	581	383·46	641	423·06	701	462·66
522	344·52	582	384·12	642	423·72	702	463·32
523	345·18	583	384·78	643	424·38	703	463·98
524	345·84	584	385·44	644	425·04	704	464·64
525	**346·50**	**585**	**386·10**	**645**	**425·70**	**705**	**465·30**
526	347·16	586	386·76	646	426·36	706	465·96
527	347·82	587	387·42	647	427·02	707	466·62
528	348·48	588	388·08	648	427·68	708	467·28
529	349·14	589	388·74	649	428·34	709	467·94
530	**349·80**	**590**	**389·40**	**650**	**429·00**	**710**	**468·60**
531	350·46	591	390·06	651	429·66	711	469·26
532	351·12	592	390·72	652	430·32	712	469·92
533	351·78	593	391·38	653	430·98	713	470·58
534	352·44	594	392·04	654	431·64	714	471·24
535	**353·10**	**595**	**392·70**	**655**	**432·30**	**715**	**471·90**
536	353·76	596	393·36	656	432·96	716	472·56
537	354·42	597	394·02	657	433·62	717	473·22
538	355·08	598	394·68	658	434·28	718	473·88
539	355·74	599	395·34	659	434·94	719	474·54
540	**356·40**	**600**	**396·00**	**660**	**435·60**	**720**	**475·20**

Links.	Feet.	Links.	Feet	Links.	Feet.	Links.	Feet.
721	475·86	781	515·46	841	555·06	901	594·66
722	476·52	782	516·12	842	555·72	902	595·32
723	477·18	783	516·78	843	556·38	903	595·98
724	477·84	784	517·44	844	557·04	904	596·64
725	**478·50**	**785**	**518·10**	**845**	**557·70**	**905**	**597·30**
726	479·16	786	518·76	846	558·36	906	597·96
727	479·82	787	519·42	847	559·02	907	598·62
728	480·48	788	520·08	848	559·68	908	599·28
729	481·14	789	520·74	849	560·34	909	599·94
730	**481·80**	**790**	**521·40**	**850**	**561·00**	**910**	**600·60**
731	482·46	791	522·06	851	561·66	911	601·26
732	483·12	792	522·72	852	562·32	912	601·92
733	483·78	793	523·38	853	562·98	913	602·58
734	484·44	794	524·04	854	563·64	914	603·24
735	**485·10**	**795**	**524·70**	**855**	**564·30**	**915**	**603·90**
736	485·76	796	525·36	856	564·96	916	604·56
737	486·42	797	526·02	857	565·62	917	605·22
738	487·08	798	526·68	858	566·28	918	605·88
739	487·74	799	527·34	859	566·94	919	606·54
740	**488·40**	**800**	**528·00**	**860**	**567·60**	**920**	**607·20**
741	489·06	801	528·66	861	568·26	921	607·86
742	489·72	802	529·32	862	568·92	922	608·52
743	490·38	803	529·98	863	569·58	923	609·18
744	491·04	804	530·64	864	570·24	924	609·84
745	**491·70**	**805**	**531·30**	**865**	**570·90**	**925**	**610·50**
746	492·36	806	531·96	866	571·56	926	611·16
747	493·02	807	532·62	867	572·22	927	611·82
748	493·68	808	533·28	868	572·88	928	612·48
749	494·34	809	533·94	869	573·54	929	613·14
750	**495·00**	**810**	**534·60**	**870**	**574·20**	**930**	**613·80**
751	495·66	811	535·26	871	574·86	931	614·46
752	496·32	812	535·92	872	575·52	932	615·12
753	496·98	813	536·58	873	576·18	933	615·78
754	497·64	814	537·24	874	576·84	934	616·44
755	**498·30**	**815**	**537·90**	**875**	**577·50**	**935**	**617·10**
756	498·96	816	538·56	876	578·16	936	617·76
757	499·62	817	539·22	877	578·82	937	618·42
758	500·28	818	539·88	878	579·48	938	619·08
759	500·94	819	540·54	879	580·14	939	619·74
760	**501·60**	**820**	**541·20**	**880**	**580·80**	**940**	**620·40**
761	502·26	821	541·86	881	581·46	941	621·06
762	502·92	822	542·52	882	582·12	942	621·72
763	503·58	823	543·18	883	582·78	943	622·38
764	504·24	824	543·84	884	583·44	944	623·04
765	**504·90**	**825**	**544·50**	**885**	**584·10**	**945**	**623·70**
766	505·56	826	545·16	886	584·76	946	624·36
767	506·22	827	545·82	887	585·42	947	625·02
768	506·88	828	546·48	888	586·08	948	625·68
769	507·54	829	547·14	889	586·74	949	626·34
770	**508·20**	**830**	**547·80**	**890**	**587·40**	**950**	**627·00**
771	508·86	831	548·46	891	588·06	951	627·66
772	509·52	832	549·12	892	588·72	952	628·32
773	510·18	833	549·78	893	589·38	953	628·98
774	510·84	834	550·44	894	590·04	954	629·64
775	**511·50**	**835**	**551·10**	**895**	**590·70**	**955**	**630·30**
776	512·16	836	551·76	896	591·36	956	630·96
777	512·82	837	552·42	897	592·02	957	631·62
778	513 48	838	553·08	898	592·68	958	632·28
779	514·14	839	553·74	899	593·34	959	632·94
780	**514·80**	**840**	**554·40**	**900**	**594·00**	**960**	**633·60**

	1/3	2/6	3/9	5/0	6/3	7/6	8/9	
	·062	·125	·187	·25	·312	·375	·437	
¼	·001	·064	·126	·189	·251	·314	·376	·439
½	·002	·065	·127	·19	·252	·315	·377	·44
¾	·003	·066	·128	·191	·253	·316	·378	·441
1	·004	4 ·067	7 ·129	10 ·192	1 ·254	4 ·317	7 ·379	10 ·442
¼	·005	·068	·13	·193	·255	·318	·38	·443
½	·006	·069	·131	·194	·256	·319	·381	·444
¾	·007	·07	·132	·195	·257	·32	·382	·445
2	·008	5 ·071	8 ·133	11 ·196	2 ·258	5 ·321	8 ·383	11 ·446
¼	·009	·072	·134	·197	·259	·322	·384	·447
½	·01	·073	·135	·198	·26	·323	·385	·448
¾	·011	·074	·136	·199	·261	·324	·386	·449
3	·012	6 ·075	9 ·137	4/0 ·2	3 ·262	6 ·325	9 ·387	9/0 ·45
¼	·014	·076	·139	·201	·264	·326	·389	·451
½	·015	·077	·14	·202	·265	·327	·39	·452
¾	·016	·078	·141	·203	·266	·328	·391	·453
4	·017	7 ·079	10 ·142	1 ·204	4 ·267	7 ·329	10 ·392	1 ·454
¼	·018	·08	·143	·205	·268	·33	·393	·455
½	·019	·081	·144	·206	·269	·331	·394	·456
¾	·02	·082	·145	·207	·27	·332	·395	·457
5	·021	8 ·083	11 ·146	2 ·208	5 ·271	8 ·333	11 ·396	2 ·458
¼	·022	·084	·147	·209	·272	·334	·397	·459
½	·023	·085	·148	·21	·273	·335	·398	·46
¾	·024	·086	·149	·211	·274	·336	·399	·461
6	·025	9 ·087	3/0 ·15	3 ·212	6 ·275	9 ·337	8/0 ·4	3 ·462
¼	·026	·089	·151	·214	·276	·339	·401	·464
½	·027	·09	·152	·215	·277	·34	·402	·465
¾	·028	·091	·153	·216	·278	·341	·403	·466
7	·029	10 ·092	1 ·154	4 ·217	7 ·279	10 ·342	1 ·404	4 ·467
¼	·03	·093	·155	·218	·28	·343	·405	·468
½	·031	·094	·156	·219	·281	·344	·406	·469
¾	·032	·095	·157	·22	·282	·345	·407	·47
8	·033	11 ·096	2 ·158	5 ·221	8 ·283	11 ·346	2 ·408	5 ·471
¼	·034	·097	·159	·222	·284	·347	·409	·472
½	·035	·098	·16	·223	·285	·348	·41	·473
¾	·036	·099	·161	·224	·286	·349	·411	·474
9	·037	2/0 ·1	3 ·162	6 ·225	9 ·287	7/0 ·35	3 ·412	6 ·475
¼	·039	·101	·164	·226	·289	·351	·414	·476
½	·04	·102	·165	·227	·29	·352	·415	·477
¾	·041	·103	·166	·228	·291	·353	·416	·478
10	·042	1 ·104	4 ·167	7 ·229	10 ·292	1 ·354	4 ·417	7 ·479
¼	·043	·105	·168	·23	·293	·355	·418	·48
½	·044	·106	·169	·231	·294	·356	·419	·481
¾	·045	·107	·17	·232	·295	·357	·42	·482
11	·046	2 ·108	5 ·171	8 ·233	11 ·296	2 ·358	5 ·421	8 ·483
¼	·047	·109	·172	·234	·297	·359	·422	·484
½	·048	·110	·173	·235	·298	·36	·423	·485
¾	·049	·111	·174	·236	·299	·361	·424	·486
1/0	·05	3 ·112	6 ·175	9 ·237	6/0 ·3	3 ·362	6 ·425	9 ·487
¼	·051	·114	·176	·239	·301	·364	·426	·489
½	·052	·115	·177	·24	·302	·365	·427	·49
¾	·053	·116	·178	·241	·303	·366	·428	·491
1	·054	4 ·117	7 ·179	10 ·242	1 ·304	4 ·367	7 ·429	10 ·492
¼	·055	·118	·18	·243	·305	·368	·43	·493
½	·056	·119	·181	·244	·306	·369	·431	·494
¾	·057	·12	·182	·245	·307	·37	·432	·495
2	·058	5 ·121	8 ·183	11 ·246	2 ·308	5 ·371	8 ·433	11 ·496
¼	·059	·122	·184	·247	·309	·372	·434	·497
½	·06	·123	·185	·248	·31	·373	·435	·498
¾	·061	·124	·186	·249	·311	·374	·436	·499

10/0 ·5	11/3 ·562	12/6 ·625	13/9 ·687	15/0 ·75	16/3 ·812	17/6 ·875	18/9 ·937
¼ ·501	¼ ·564	¼ ·626	¼ ·689	¼ ·751	¼ ·814	¼ ·876	¼ ·939
½ ·502	½ ·565	½ ·627	½ ·69	½ ·752	½ ·815	½ ·877	½ ·94
¾ ·503	¾ ·566	¾ ·628	¾ ·691	¾ ·753	¾ ·816	¾ ·878	¾ ·941
1 ·504	4 ·567	7 ·629	10 ·692	1 ·754	4 ·817	7 ·879	10 ·942
¼ ·505	¼ ·568	¼ ·63	¼ ·693	¼ ·755	¼ ·818	¼ ·88	¼ ·943
½ ·506	½ ·569	½ ·631	½ ·694	½ ·756	½ ·819	½ ·881	½ ·944
¾ ·507	¾ ·57	¾ ·632	¾ ·695	¾ ·757	¾ ·82	¾ ·882	¾ ·945
2 ·508	5 ·571	8 ·633	11 ·696	2 ·758	5 ·821	8 ·883	11 ·946
¼ ·509	¼ ·572	¼ ·634	¼ ·697	¼ ·759	¼ ·822	¼ ·884	¼ ·947
½ ·51	½ ·573	½ ·635	½ ·698	½ ·76	½ ·823	½ ·885	½ ·948
¾ ·511	¾ ·574	¾ ·636	¾ ·699	¾ ·761	¾ ·824	¾ ·886	¾ ·949
3 ·512	6 ·575	9 ·637	14/0 ·7	3 ·762	6 ·825	9 ·887	19/0 ·95
¼ ·514	¼ ·576	¼ ·639	¼ ·701	¼ ·764	¼ ·826	¼ ·889	¼ ·951
½ ·515	½ ·577	½ ·64	½ ·702	½ ·765	½ ·827	½ ·89	½ ·952
¾ ·516	¾ ·578	¾ ·641	¾ ·703	¾ ·766	¾ ·828	¾ ·891	¾ ·953
4 ·517	7 ·579	10 ·642	1 ·704	4 ·767	7 ·829	10 ·892	1 ·954
¼ ·518	¼ ·58	¼ ·643	¼ ·705	¼ ·768	¼ ·83	¼ ·893	¼ ·955
½ ·519	½ ·581	½ ·644	½ ·706	½ ·769	½ ·831	½ ·894	½ ·956
¾ ·52	¾ ·582	¾ ·645	¾ ·707	¾ ·77	¾ ·832	¾ ·895	¾ ·957
5 ·521	8 ·583	11 ·646	2 ·708	5 ·771	8 ·833	11 ·896	2 ·958
¼ ·522	¼ ·584	¼ ·647	¼ ·709	¼ ·772	¼ ·834	¼ ·897	¼ ·959
½ ·523	½ ·585	½ ·648	½ ·71	½ ·773	½ ·835	½ ·898	½ ·96
¾ ·524	¾ ·586	¾ ·649	¾ ·711	¾ ·774	¾ ·836	¾ ·899	¾ ·961
6 ·525	9 ·587	13/0 ·65	3 ·712	6 ·775	9 ·837	18/0 ·9	3 ·962
¼ ·526	¼ ·589	¼ ·651	¼ ·714	¼ ·776	¼ ·839	¼ ·901	¼ ·964
½ ·527	½ ·59	½ ·652	½ ·715	½ ·777	½ ·84	½ ·902	½ ·965
¾ ·528	¾ ·591	¾ ·653	¾ ·716	¾ ·778	¾ ·841	¾ ·903	¾ ·966
7 ·529	10 ·592	1 ·654	4 ·717	7 ·779	10 ·842	1 ·904	4 ·967
¼ ·53	¼ ·593	¼ ·655	¼ ·718	¼ ·78	¼ ·843	¼ ·905	¼ ·968
½ ·531	½ ·594	½ ·656	½ ·719	½ ·781	½ ·844	½ ·906	½ ·969
¾ ·532	¾ ·595	¾ ·657	¾ ·72	¾ ·782	¾ ·845	¾ ·907	¾ ·97
8 ·533	11 ·596	2 ·658	5 ·721	8 ·783	11 ·846	2 ·908	5 ·971
¼ ·534	¼ ·597	¼ ·659	¼ ·722	¼ ·784	¼ ·847	¼ ·909	¼ ·972
½ ·535	½ ·598	½ ·66	½ ·723	½ ·785	½ ·848	½ ·91	½ ·973
¾ ·536	¾ ·599	¾ ·661	¾ ·724	¾ ·786	¾ ·849	¾ ·911	¾ ·974
9 ·537	12/0 ·6	3 ·662	6 ·725	9 ·787	17/0 ·85	3 ·912	6 ·975
¼ ·539	¼ ·601	¼ ·664	¼ ·726	¼ ·789	¼ ·851	¼ ·914	¼ ·976
½ ·54	½ ·602	½ ·665	½ ·727	½ ·79	½ ·852	½ ·915	½ ·977
¾ ·541	¾ ·603	¾ ·666	¾ ·728	¾ ·791	¾ ·853	¾ ·916	¾ ·978
10 ·542	1 ·604	4 ·667	7 ·729	10 ·792	1 ·854	4 ·917	7 ·979
¼ ·543	¼ ·605	¼ ·668	¼ ·73	¼ ·793	¼ ·855	¼ ·918	¼ ·98
½ ·544	½ ·606	½ ·669	½ ·731	½ ·794	½ ·856	½ ·919	½ ·981
¾ ·545	¾ ·607	¾ ·67	¾ ·732	¾ ·795	¾ ·857	¾ ·92	¾ ·982
11 ·546	2 ·608	5 ·671	8 ·733	11 ·796	2 ·858	5 ·921	8 ·983
¼ ·547	¼ ·609	¼ ·672	¼ ·734	¼ ·797	¼ ·859	¼ ·922	¼ ·984
½ ·548	½ ·61	½ ·673	½ ·735	½ ·798	½ ·86	½ ·923	½ ·985
¾ ·549	¾ ·611	¾ ·674	¾ ·736	¾ ·799	¾ ·861	¾ ·924	¾ ·986
11/0 ·55	3 ·612	6 ·675	9 ·737	16/0 ·8	3 ·862	6 ·925	9 ·987
¼ ·551	¼ ·614	¼ ·676	¼ ·739	¼ ·801	¼ ·864	¼ ·926	¼ ·989
½ ·552	½ ·615	½ ·677	½ ·74	½ ·802	½ ·865	½ ·927	½ ·99
¾ ·553	¾ ·616	¾ ·678	¾ ·741	¾ ·803	¾ ·866	¾ ·928	¾ ·991
1 ·554	4 ·617	7 ·679	10 ·742	1 ·804	4 ·867	7 ·929	10 ·992
¼ ·555	¼ ·618	¼ ·68	¼ ·743	¼ ·805	¼ ·868	¼ ·93	¼ ·993
½ ·556	½ ·619	½ ·681	½ ·744	½ ·806	½ ·869	½ ·931	½ ·994
¾ ·557	¾ ·62	¾ ·682	¾ ·745	¾ ·807	¾ ·87	¾ ·932	¾ ·995
2 ·558	5 ·621	8 ·683	11 ·746	2 ·808	5 ·871	8 ·933	11 ·996
¼ ·559	¼ ·622	¼ ·684	¼ ·747	¼ ·809	¼ ·872	¼ ·934	¼ ·997
½ ·56	½ ·623	½ ·685	½ ·748	½ ·81	½ ·873	½ ·935	½ ·998
¾ ·561	¾ ·624	¾ ·686	¾ ·749	¾ ·811	¾ ·874	¾ ·936	¾ ·999

CHAPTER XXIV.

STAMP LAWS RECENTLY PASSED

In relation to the Duties for the several purposes of Trade, and for the Conveyance and Disposal of Property, together with the Duties on Imports.

AN ACT TO AMEND THE LAWS RELATING TO STAMP DUTIES.

FROM and after the tenth day of *October* one thousand eight hundred and fifty-three the several stamp duties now payable in *Great Britain* and *Ireland* respectively, under or by virtue of any Act or Acts of Parliament for or in respect of the several instruments, matters, and things mentioned or described (otherwise than by way of exception) in the schedule to this act annexed, and whereon other duties are by this act granted, shall respectively cease and determine, and shall be and the same are hereby repealed; and in lieu and instead thereof there shall be granted, raised, levied, collected, and paid in and throughout the United Kingdom of *Great Britain* and *Ireland*, for and in respect of things described in the said schedule, or for or in respect of the vellum, parchment, or paper upon which any of them respectively shall be written, the several duties or sums of money set down in figures against the same respectively, or otherwise specified and set forth in the said schedule, which said schedule, and the several provisions, regulations, directions and exemptions therein contained with respect to the said duties, and the instruments, matters, and things charged therewith or exempted therefrom shall be deemed and taken to be part of this act, and shall be applied, observed, and put in execution accordingly: Provided always, that nothing herein contained shall extend to repeal or alter any of the said stamp duties now payable in relation to any deed or instrument which shall have been signed or executed by any party thereto, or which shall bear date before or upon the tenth day of *October* one thousand eight hundred and fifty-three.

Stamps for receipts and drafts.

The duties of one penny by this act granted on receipts and on drafts or orders for the payment of money respectively may be denoted either by a stamp impressed upon the paper whereon any such instrument is written or by an adhesive stamp affixed thereto, and the Commissioners of Inland Revenue shall provide stamps of both descriptions for the purpose of denoting the said duties.

In any case where an adhesive stamp shall be used for the purpose aforesaid on any receipt or upon any draft or order respectively chargeable with the duty of one penny by this act, the person by whom such receipt shall be given or such draft or order signed or made shall, before the instrument shall be delivered out of his hands, custody, or power, cancel or obliterate the stamp so used, by writing thereon his name or the initial letters of his name so and in such a manner as to show clearly and distinctly that such stamp has been made use of, and so that the same may not be again used; and if any person who shall write or give any such receipt or discharge or make or sign any such draft or order with any

adhesive stamp thereon, shall not *bonâ fide* in manner aforesaid effectually cancel or obliterate such stamp, he shall forfeit the sum of ten pounds.

Penalty for committing frauds.

If any person shall fraudulently get off or remove, or cause or procure to be gotten off or removed, from any paper whereon any receipt or any draft or order shall be written, any adhesive stamp, or if any person shall affix or use any such stamp which shall have been gotten off or removed from any paper whereon any receipt or any draft or order shall have been written, to or for any receipt, draft, or order, or any paper whereon any such receipt, draft, or order shall be or be intended to be written; or if any person shall do or practise, or be concerned in any fraudulent act, contrivance, or device whatever, not specially provided for by this or some other Act of Parliament, with intent or design to defraud Her Majesty of any duty by this act granted upon receipts or upon drafts or orders, every person so offending in any of the said several cases shall forfeit the sum of twenty pounds.

For better securing the stamp duties by law chargeable on policies of insurance upon lives, and for preventing frauds in respect of any such insurances:

Stamps for policy of insurances.

Every person who shall make or agree to make, or shall receive any premium or valuable consideration for making, any assurance or insurance upon any life or lives, or upon any event or contingency relating to or depending upon any life or lives, shall, within one calendar month after the payment or giving of any such premium or consideration, make out and sign or execute, or cause and procure to be made out and signed or executed upon vellum, parchment, or paper, duly stamped, a policy of such assurance or insurance, and have the same ready to be delivered to the party entitled thereto, and shall upon demand made by any such party, or any agent in that behalf duly authorized, deliver the same to him, or in default in any of the cases aforesaid shall forfeit the sum of fifty pounds:

Every person who at the time of the payment or giving of any such premium or consideration shall be a managing director of or the secretary to or other principal officer of any society or company receiving any such premium or consideration, shall be deemed to be a person making or agreeing to make such assurance or insurance, and shall be subject and liable to the penalty by this act imposed for any such default as aforesaid.

Articles of clerkship to attorneys.

Whereas by an act passed in the fifty-fifth year of the reign of King *George* the Third, chapter one hundred and eighty-four certain stamp duties are imposed on any articles of clerkship or contract whereby any person shall first become bound to serve as a clerk in order to his admission as an attorney or solicitor in any court; that is to say, in order to admission in any of the Courts at *Westminster*, the stamp duty of one hundred and twenty pounds, and in order to admission in any of the Courts of the Counties Palatine, the stamp duty of sixty pounds: And whereas where any person has become bound and has served as a clerk under any such articles or contract stamped with the said duty of sixty pounds in order to his admission as an attorney or solicitor in any of

the Courts of the Counties Palatine, he is capable of being admitted in any of Her Majesty's Courts at *Westminster*, but only upon the payment of the further stamp duty of one hundred and twenty pounds; and it is expedient to afford relief in such cases:

Where any person shall have become bound as a clerk in order to his admission as an attorney or solicitor in any of the Courts of the Counties Palatine by articles or contract stamped with the said duty of sixty pounds, then upon payment of such further sum of money as with the said duty of sixty pounds will make up the full stamp duty which, at the date of such articles or contract, was payable by law on articles of clerkship in order to admission in any of the Courts at *Westminster*, it shall be lawful for the Commissioners of Inland Revenue and they are hereby required to stamp the said articles or contract with a stamp or stamps to denote such further duty, and thereupon such articles or contract shall be as valid and effectual for entitling such person to admission in any of the Courts at *Westminster* as if the same had been duly stamped with such full duty in the first instance.

And whereas by an act passed in the forty-eighth year of the reign of King *George* the Third, chapter one hundred and forty-nine, section thirty-eight, persons intromitting with or entering upon the possession or management of any personal or moveable estate or effects in *Scotland* of any person dying, are required to exhibit a full and true inventory, duly stamped, to be recorded as in the said act is provided, of all the personal or moveable estate and effects of the deceased already recovered or known to be existing; and if at any subsequent period a discovery shall be made of any other effects belonging to the deceased, an additional inventory of the same is in like manner to be exhibited and recorded; and every such additional inventory is chargeable by law with the full *ad valorem* stamp duty payable in respect of the total amount or value of the estate and effects specified therein, and in any such former inventory; and thereupon the party exhibiting the same is entitled to receive back the amount of the stamp duty paid on such former inventory; and it is expedient to prevent the inconvenience attending the over-payment of the stamp duty in such cases by charging on any such additional inventory the deficient stamp duty only.

For inventories in Scotland.

Every such additional inventory to be made and recorded as aforesaid shall be chargeable only with such amount of stamp duty as, together with the stamp duty charged upon any former duly stamped inventory of the estate and effects of the same deceased person already exhibited and recorded, shall make up the full amount of stamp duty chargeable by law in respect of the total amount or value of all the estate and effects of the said deceased specified in the said additional and any such former inventory.

No license granted to any spiritual person to perform divine service in any building approved by the bishop in lieu of any church or chapel whilst the same is under repair or is rebuilding, or in any building so approved for the convenience of the inhabitants of a parish resident at a distance

from the church or consecrated chapel, shall be chargeable with any stamp duty.

And whereas by the said act passed in the fifty-fifth year of the reign of King *George* the Third, it is provided that where any property is sold and conveyed subject to any debt or sum of money to be afterwards paid by the purchaser, the same shall be deemed to be purchase or consideration money in respect whereof the said *ad valorem* duty charged upon the sale and conveyance of property is to be paid: And whereas it has been held and determined that the said *ad valorem* duty is payable in respect of any such sum or debt only where the purchaser is personally liable or bound, or undertakes or agrees to pay the same or to indemnify the vendor against the same; and it is expedient to alter and amend the law in this respect:

Sale and conveyance of land, &c.

Where any lands or other property shall be sold and conveyed subject to any mortgage, wadset, or bond or other debt, or to any gross or entire sum of money, such sum of money or debt shall be deemed the purchase or consideration money, or part of the purchase or consideration money, as the case may be, in respect whereof the said *ad valorem* duty shall be paid, notwithstanding the purchaser shall not be or become personally liable or shall not undertake or agree to pay the same or to indemnify the vendor or any person against the same, anything in any act or otherwise to the contrary notwithstanding.

And whereas it has been adjudged and determined by law that upon the sale of property, where the consideration expressed in the conveyance is a rent charge or an annuity, made subject to redemption or repurchase, *ad valorem* stamp duty is chargeable under the act passed in the Session of Parliament held in the thirteenth and fourteenth years of Her Majesty, chapter ninety-seven, only where such redemption or repurchase may be enforced at the option of the vendor, and it is expedient that such duty should be chargeable in all cases where such rentcharge or annuity is made redeemable.

In any case where property shall be sold and conveyed in consideration of any rentcharge or annuity, or any annual or periodical payment to be made permanently or for any indefinite period, so that the total amount of the money to be paid for such property cannot be previously ascertained, which rentcharge, annuity, or other payment shall be made subject to redemption or purchase upon terms and conditions specified in the deed or instrument whereby the property sold shall be conveyed to or vested in the purchaser, or any person by his direction, the money or the consideration mentioned in the said deed or instrument as that on payment or transfer, delivery or satisfaction, of which the said rentcharge, annuity, or other payment shall be redeemed or purchased or repurchased, or shall cease to be payable, shall be deemed to be the purchase money or consideration on the sale of the said property so sold and conveyed, and in respect of which last-mentioned purchase money or consideration the *ad valorem* duty shall be chargeable; and where any such last-mentioned consideration shall consist wholly or in part of any stock or security mentioned in the said act, the value thereof shall be ascertained as in such act

is in that behalf provided; and where any such annuity, rentcharge, or other payment aforesaid shall be made subject to redemption or purchase or repurchase or discontinuance upon payment or satisfaction of any money or value to be ascertained or calculated in manner provided in the said deed or instrument, the amount of such money or value shall, for the purpose of charging the said *ad valorem* duty, be ascertained or calculated as in such deed or instrument shall be so provided.

And whereas by the said act of the thirteenth and fourteenth years of Her Majesty, chapter ninety-seven, a stamp duty of five shillings was granted and imposed upon the duplicate or counterpart of any deed or instrument chargeable with stamp duty (exclusive of progressive duty) to the amount of five shillings or upwards; and it is provided that in such case the duplicate or counterpart shall not be available unless stamped with a particular stamp for denoting or testifying the payment of the full and proper stamp duty on the original deed or instrument; and it is expedient to dispense with the said particular stamp on counterparts of leases:

Notwithstanding anything contained in the said act, the counterpart of any lease of lands, tenements, or hereditaments, being duly stamped with the said stamp duty of five shillings, or any higher stamp duty (exclusive of progressive duty), and not being executed or signed by or on the behalf of any lessor or grantor, shall be available as a counterpart without being stamped with a particular stamp for denoting or testifying the payment of the stamp duty chargeable on the original lease.

And whereas by the said act of the thirteenth and fourteenth years of Her Majesty, when any deed or instrument shall be presented to the Commissioners of Inland Revenue, and the fee of ten shillings shall be paid to them for their opinion as to the stamp duty with which such deed or instrument in their judgment is chargeable, the said commissioners are required to assess and charge the stamp duty on such deed or instrument, and, on the same being duly stamped, to impress thereon a particular stamp to signify and denote that the full amount of stamp duty with which such deed or instrument is by law chargeable has been paid: And whereas the said Commissioners are not authorized to impress a particular stamp upon any deed or instrument not chargeable with any stamp duty in order to denote that the same is not so chargeable; and it is expedient that provision should be made for that purpose.

It shall be lawful for any person to present to the said commissioners any deed or instrument, and upon payment of the fee of ten shillings, as in the said act is mentioned, to require their opinion whether or not the same is chargeable with any stamp duty, and if the said commissioners shall be of opinion that such deed or instrument is not chargeable with any stamp duty, it shall be lawful for them and they are hereby required to impress thereon a particular stamp, to be provided by them for that purpose, with such word or words, or device or symbol thereon as they shall think proper in that behalf, which shall signify and denote that such deed is not chargeable with any stamp duty; and every such deed or instrument upon

which the said stamp shall be impressed shall be deemed to be not so chargeable, and shall be receivable in evidence in all courts of law and equity, notwithstanding any objection made to the same as being chargeable with stamp duty, and not stamped to denote the same: Provided always, that if the said commissioners shall assess and charge any stamp duty upon or in respect of any such deed or instrument, and the party presenting the same and paying such duty shall declare himself dissatisfied with their determination, it shall be lawful for him to appeal against the same to Her Majesty's Court of Exchequer, on the terms and in the manner in the said act provided; and the said court shall hear and determine the appeal, and decide whether the said deed or instrument is chargeable with any, and if any, what stamp duty; and if the court shall be of opinion that the same is not so chargeable, or is chargeable with a less amount of duty than shall have been assessed and charged thereon, then the amount of such duty or of the excess (as the case may be) shall be returned to the appellant, together with the sum deposited as in the said act mentioned; and if the court shall be of opinion that any further duty is chargeable on the said deed or instrument, such further duty shall be paid to the said commissioners, and the court shall order and enforce the payment thereof accordingly.

And whereas it would facilitate the transfer of the bonds and mortgages given by public companies under the provisions of Acts of Parliament as securities for money which such companies are by the said acts expressly empowered or authorized to borrow, if the transfers or assignments of such bonds or mortgages were endorsed thereon, and were exempted from stamp duty, and it is expedient to grant such exemption in consideration of a composition stamp duty being paid on such bonds and mortgages on the original making and issuing thereof, in lieu of the stamp duty with which such transfers or assignments would otherwise be chargeable:

Transfers of bonds and mortgages.

Where on the original making and issuing of any such bond or mortgage as aforesaid, and before any transfer or assignment thereof, the same shall be stamped with an amount of stamp duty equal to three times the amount of the *ad valorem* stamp duty chargeable thereon by law, and over and above the said *ad valorem* duty, then every transfer or assignment thereafter made of such bond or mortgage by endorsement thereon shall be deemed to be exempt from the stamp duty which would otherwise be payable in respect of such transfer or assignment: Provided always, that nothing herein contained shall extend to exempt any such transfer or assignment from any stamp duty to which it may be liable as a settlement of the money or stock secured by such bond or mortgage, or any portion thereof.

And whereas it is desirable to facilitate the purchase of stamped paper, covers, or envelopes, and of other stamps for expressing or denoting the rates or duties of postage (all of which are hereinafter designated as postage stamps), and for that purpose to enable certain persons in the service of the Post Office to sell postage stamps without having any such license

as the laws now in force require in that behalf, and without being subject or liable to any penalty for carrying about postage stamps for sale:

Persons authorized by Postmaster General may sell postage stamps.

It shall be lawful for the Postmaster General by writing under his hand to authorize and appoint any person in the service or employment of the Post Office to sell postage stamps at any particular house or place to be specified for that purpose, and also any messenger or other person employed in the delivery of letters sent by post to carry about for sale and to sell at any place postage stamps, and all such persons shall, during the period that such authority and appointment shall remain in force and unrevoked, without any license or any authority other than last aforesaid, be at liberty to sell at any house or place to be specified as aforesaid, or if so authorized, to carry about for sale and sell at any place, any postage stamps, and such persons respectively shall not be subject or liable to any penalty or forfeiture for so doing, anything in any act or acts to the contrary notwithstanding.

For preventing the evasion of the duties on playing cards

And whereas by an act passed in the ninth year of the reign of King *George* the Fourth, chapter eighteen, granting stamp duties upon playing cards made fit for sale or use in the United Kingdom, such duties to be denoted on the ace of spades of each pack of cards, it is enacted that no playing cards shall be sold as waste cards unless a corner of each card shall be cut off at least half an inch in depth, and other provisions are therein contained for securing the said duties: And whereas packs or parcels of cards fit and intended for use and play, but not containing an ace of spades duly stamped, are commonly sold under the pretence of being waste cards, each of such cards having a corner cut off, whereby the said duties are evaded; and it is expedient to prevent such practice:

No playing cards, except such as shall be *bonâ fide* spoiled and rendered unfit for use as playing cards in the process of manufacture, and which shall have a corner cut off as in the said last-mentioned act is provided, nor any cards commonly called or known as picture cards or court cards, shall be deemed to be waste cards; and no playing cards, except waste cards, shall be sold otherwise than in packs each pack containing fifty-two cards of the four usual suits of thirteen cards each, including an ace of spades duly stamped for denoting the duty by the said act granted on a pack of cards, and tied up together in manner directed by the said act; and if any person shall sell or expose or keep for sale any playing cards, not being a pack of cards as aforesaid, and the same not being *bonâ fide* waste cards within the meaning of this act, he shall for every pack, parcel, or separate quantity of cards so sold or exposed or kept for sale forfeit, if he shall not be a licensed maker of playing cards, the sum of ten pounds, and if he shall be such licensed maker the sum of twenty pounds; and all cards so sold or exposed or kept for sale shall be forfeited, and may be seized and taken by any Officer of Inland Revenue, and be disposed of as the Commissioners of Inland Revenue shall direct; provided that if in any proceeding any question shall arise whether any cards are or were *bonâ*

fide waste cards or not, proof of the affirmative thereof shall lie on the party selling the same or having or keeping the same for sale.

And whereas by an act passed in the session held in the seventh and eighth years of the reign of King *George* the Fourth, chapter fifty-three, Officers of Excise and persons employed in the collection or management of or accounting for the revenue of excise are exempted from serving as mayor or sheriff, or in any corporate or parochial or other public office or employment, or on any jury or inquest, or in the Militia; and it is expedient to extend the same to all other officers appointed by or under the Commissioners of Inland Revenue.

No officer or person appointed by the Commissioners of Inland Revenue, or employed by them or under their authority or direction in any way relating to any of the duties under their care or management shall, so long as he shall continue in and exercise such last-mentioned office or employment, be compelled to serve as mayor or sheriff, or in any of the offices, employments, or capacities in the said act and herein before in that behalf mentioned.

Allowance for receipt stamps on hand.

Where any person shall be possessed of any stamps rendered useless by this act, it shall be lawful for the Commissioners of Inland Revenue, on application to them or to their proper officer in that behalf, at any time within six calendar months after the commencement of this act to cancel and make allowance for the same, as in the case of spoiled stamps, after deducting the discount by law granted on the purchase of receipt stamps.

Drafts on bankers.

Provided always, that any draft or order drawn upon a banker for a sum of money payable to order on demand which shall, when presented for payment, purport to be endorsed by the person to whom the same shall be drawn payable, shall be a sufficient authority to such banker to pay the amount of such draft or order to the bearer thereof; and it shall not be incumbent on such banker to prove that such endorsement, or any subsequent endorsement, was made by or under the direction or authority of the person to whom the said draft or order was or is made payable either by the drawer or any endorser thereof.

And whereas by an act passed in the Session of Parliament held in the fifth and sixth years of Her Majesty's reign, chapter eighty-two, certain rates and duties denominated stamp duties were granted and made payable in *Ireland* for a limited term; and by four several acts passed respectively in the eighth, eleventh, fourteenth, and fifteenth years of Her Majesty's reign the same rates and duties were continued for four other several and successive terms, the last of which will expire on the tenth day of *October* one thousand eight hundred and fifty-three; and it is expedient to make the said rates and duties perpetual:

Stamp duties in Ireland.

All the several sums of money and duties and composition for duties granted and made payable in *Ireland* by the said act of the fifth and sixth years of Her Majesty, chapter eighty-two, and not repealed by any subsequent act, and also all duties now payable in lieu or instead of any of the said duties which may have been so repealed,

shall be and the same are hereby continued and made perpetual, and shall be charged, raised, levied, collected, and paid unto and for the use of Her Majesty, her heirs and successors for ever: The said act of the fifth and sixth years of Her Majesty, and all and every other act, and acts now in force in relation to the duties and composition for duties which are continued by this act, shall severally be continued and remain in full force in all respects in relation to the said duties and composition for duties hereby continued and granted, and all and every the powers and authorities, rules, regulations, directions, penalties, forfeitures, clauses, matters, and things contained in the said acts or any of them, and in force as aforesaid, shall severally and respectively be duly observed, practised, applied, and put in execution in relation to the said duties and composition for duties hereby continued and granted, for the charging, raising, levying, paying, accounting for, and securing of the said duties and composition for duties, and all arrears thereof, and for the preventing, detecting, and punishing of all frauds, forgeries, and other offences relating thereto, as fully and effectually to all intents and purposes as if the same powers, authorities, rules, regulations, directions, penalties, forfeitures, clauses, matters, and things were particularly repeated and re-enacted in the body of this act with reference to the said duties and composition for duties hereby granted.

The Schedule referred to by this Act.

	Duty. £	s.	d.
Apprenticeship and Clerkship.—Indenture or other instrument or writing containing the covenants, articles, or agreements for or relating to the service of any apprentice, clerk, or servant who shall be put or placed to or with any master or mistress, or to or with any new master or mistress, either by assignment, transfer, or turn-over, or upon the death, absence, or incapacity of the former master or mistress, or otherwise, to learn any profession, trade, or employment whatsoever (except articles of clerkship or apprenticeship to any attorney, solicitor, or other person in order to admission in any court, or in any office in any court), or any writing whatever (except as aforesaid) whereby any such assignment, transfer, or turn-over may be effectuated or ascertained;			
Where no sum of money or other matter or thing shall be paid, given, assigned, or conveyed, or be secured to be paid, given, assigned, or conveyed to or for the use or benefit of the master or mistress, with or in respect of any apprentice, clerk, or servant	0	2	6
Debenture or certificate for entitling any person to receive any drawback of any duty or duties, or part of any duty or duties of customs or excise, or any bounty payable out of the revenue of customs or excise, for or in respect of any goods, wares, or merchandise exported or shipped to be exported from any part of the United Kingdom to any part beyond the sea;			
Where the drawback or bounty to be received shall not exceed ten pounds	0	1	0
Where the same shall exceed ten pounds and not exceed fifty pounds	0	2	6
And where the same shall exceed fifty pounds	0	5	0

	Duty. £ s. d.
Draft or order for the payment of any sum of money to the bearer or to order, on demand	0 0 1

And the following instruments shall be deemed and taken to be drafts or orders for the payment of money within the intent and meaning of this act, and of any act or acts relating to the stamp duties on bills of exchange, drafts, or orders, and shall be chargeable accordingly with the stamp duties imposed by this act or any such act or acts; viz.

All documents or writings usually termed Letters of Credit, or whereby any person to whom any such document or writing is or is intended to be delivered or sent shall be entitled, or be intended to be entitled to have credit with, or in account with, or to draw upon any other person for, or to receive from such other person any sum of money therein mentioned.

Exemptions from the Duties on Drafts or Orders.

All drafts or orders for the payment of money to the bearer on demand, drawn upon any banker or bankers, now by law exempt from stamp duty.

All letters of credit, whether in sets or not, sent by persons in the United Kingdom to persons abroad authorizing drafts on the United Kingdom.

Policy of assurance or insurance, or other instrument, by whatever name the same shall be called, whereby any insurance shall be made upon any life or lives, or upon any event or contingency relating to or depending upon any life or lives;	
Where the sum insured shall not exceed five hundred pounds;	
Then for every fifty pounds, and any fractional part of fifty pounds	0 0 6
And where it shall exceed five hundred pounds, and shall not exceed one thousand pounds;	
Then for every one hundred pounds, and any fractional part of one hundred pounds	0 1 0
And where it shall exceed one thousand pounds;	
Then for every one thousand pounds, and any fractional part of one thousand pounds	0 10 0
Receipt or discharge given for or upon the payment of money amounting to two pounds or upwards	0 0 1

Exemption.

Receipts given for money deposited in any Bank, or in the hands of any banker, to be accounted for, whether with interest or not; provided the same be not expressed to be received of or by the hands of any other than the person to whom the same is to be accounted for: Provided always, that this exemption shall not extend to receipts or acknowledgments for sums paid or deposited for or upon letters of allotment or shares or in respect of calls upon any scrip or shares of or in any Joint Stock or other Company or proposed or intended company, which said last-mentioned receipts or acknowledgments, by whomsoever given, shall be liable to the duty by this act charged on receipts.

Repeal of certain Stamp Duties, and to grant others in lieu thereof, to give relief with respect to the Stamp Duties on Newspapers and Supplements thereto, to repeal the Duty on Advertisements, and otherwise to amend the Laws relating to Stamp Duties.

Whereas it is expedient to repeal the stamp duties now payable in respect of the several instruments, matters and things mentioned or described in the schedule to this act annexed, and to impose other stamp duties in lieu thereof, and also to give relief with respect to the stamp duties on newspapers and supplements thereto, and otherwise to amend the laws relating to stamp duties, and to repeal the duty charged on advertisements: Be it therefore enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the lords spiritual and temporal, and commons, in this present parliament assembled, and by the authority of the same, as follows:

Stamp duties on instruments in the schedule annexed repealed, and others granted in lieu thereof.

From and after the passing of this act the several stamp duties now payable in *Great Britain* and *Ireland* respectively, under or by virtue of any Act or Acts of Parliament for or in respect of the several instruments, matters and things mentioned or described in the schedule to this act annexed, and whereon other duties are by this act granted, shall respectively cease and determine, and shall be and the same are hereby repealed; and in lieu and instead thereof there shall be granted, raised, levied, collected, and paid in and throughout the United Kingdom of *Great Britain* and *Ireland*, to and to the use of Her Majesty, her heirs and successors, for and in respect of the several instruments, matters, and things described or mentioned in the said schedule, or for or in respect of the vellum, parchment, or paper upon which any of them respectively shall be written, the several duties or sums of money set down in figures against the same respectively, or otherwise specified and set forth in the said schedule, which said schedule, and the several provisions, regulations, and directions therein contained with respect to the said duties, and the instruments, matters, and things charged therewith, shall be deemed and taken to be part of this act, and shall be applied, observed, and put in execution accordingly: provided always, that nothing herein contained shall extend to repeal or alter any of the said stamp duties now payable in relation to any deed or instrument which shall have been signed or executed by any party thereto, or which shall bear date before or upon the passing of this act.

The new duties to be denominated stamp duties, &c.

The said duties by this act granted shall be denominated and deemed to be stamp duties, and shall be under the care and management of the Commissioners of Inland Revenue for the time being; and all the powers, provisions, clauses, regulations, directions, allowances, and exemptions, fines, forfeitures, pains, and penalties contained in or imposed by any act or acts, or any schedule thereto, relating to any duties of the same kind or description heretofore payable in *Great Britain* and *Ireland* respectively, and in force at the time of the passing of this act, shall respectively be in full force and effect with respect to the duties by this act granted, and to the vellum, parchment, and paper,

instruments, matters, and things charged and chargeable therewith, and to the persons liable to the payment of the said duties, so far as the same are or shall be applicable in all cases not hereby expressly provided for, and shall be observed, applied, allowed, enforced, and put in execution for and in the raising, levying, collecting, and securing of the said duties hereby granted, and otherwise in relation thereto, so far as the same shall not be superseded by, and shall be consistent with the express provisions of this act, as fully and effectually to all intents and purposes as if the same had been herein repeated and specially enacted, *mutatis mutandis*, with reference to the said duties by this act granted.

As to duties on newspapers and supplements.

No higher stamp duty than one penny shall be chargeable on any newspaper printed on one sheet of paper containing a superficies not exceeding two thousand two hundred and ninety-five inches:

A supplement published with any newspaper duly stamped with the duty of one penny, such supplement being printed on one sheet of paper only, and together with such newspaper containing in the aggregate a superficies not exceeding two thousand two hundred and ninety-five inches, shall be free from stamp duty:

Any other supplement to any such duly stamped newspaper shall not be chargeable with any higher stamp duty than one halfpenny, provided it does not contain a superficies exceeding one thousand one hundred and forty-eight inches:

And any two supplements to any such duly stamped newspaper shall not be chargeable with any higher stamp duty than one halfpenny on each, provided each of such supplements be printed and published on one sheet of paper only, and that they contain together a superficies not exceeding in the aggregate two thousand two hundred and ninety-five inches:

The superficies in all the cases aforesaid to be one side only of the sheet of paper, and exclusive of the margin of the letter press.

Allowance for newspaper stamps on hand.

Where any person shall be possessed of any stamps for newspapers rendered useless by this act, it shall be lawful for the Commissioners of Inland Revenue, on application to them or to their proper officer in that behalf, at any time within six calendar months after the commencement of this act, to cancel and make allowance for the same, as in the case of spoiled stamps

After passing of this act all duties on advertisements to cease.

And whereas it is expedient to repeal the duties now payable on advertisements: From and after the passing of this act the duties now payable under any act or acts in force for or in respect of any advertisement contained in or published with any gazette or other newspaper, or contained in or published with any other periodical paper, or in or with any pamphlet or literary work, and all enactments, clauses, provisions, and regulations for levying, collecting, and securing the said duties; but so far only as they relate to such duties, shall respectively cease and determine, and shall be and the same are hereby repealed, save and except as to any of the said duties, which shall have been charged or incurred on or before the day of the passing of this act, and any arrear

thereof, and as to all fines and penalties incurred or which may be incurred in respect of the said duties or arrears, all which said duties and arrears, fines and penalties, so excepted as aforesaid, shall respectively be sued for, recovered, levied, paid, and applied in the same manner as if this act had not been passed.

Duties on assignments of Judgment in Ireland, and writs of acknowledgment in Scotland.

Whereas it is expedient to remove doubts which have arisen as to the stamp duties upon assignments of Judgment in *Ireland;* and it is also expedient to reduce the stamp duties now chargeable in *Scotland* upon writs of acknowledgment by persons infeft of lands in favour of the heirs or disponees of creditors: In lieu of the stamp duties now payable upon the instruments hereinafter mentioned there shall be chargeable (besides any progressive duties to which the same respectively may be liable by reference to the head of progressive duty in the schedule to the act of the thirteenth and fourteenth years of her present Majesty, chapter ninety-seven,) the respective stamp duties following; (that is to say,)

For and upon every assignment of any judgment in *Ireland*, one pound fifteen shillings:

And for and upon any writ of acknowledgment by any person infeft of lands in *Scotland* in favour of the heir or disponee of a creditor fully vested in right of an heritable security constituted by infeftment, ten shillings.

And whereas under and by virtue of certain Acts of Parliament now in force the governor and company of the bank of *Scotland*, and the royal bank of *Scotland* and the *British* linen company in *Scotland* are respectively authorized and empowered to make an issue and re-issue their promissory notes payable to bearer on demand on unstamped paper, giving security, and keeping and producing true accounts of all the notes so issued by them respectively, and accounting for and paying the stamp duties payable in respect of such notes: And whereas it is expedient to authorize and empower the commissioners of Her Majesty's Treasury to compound with the said banks, as well as all bankers in *Scotland*, for the stamp duties on their promissory notes payable to bearer on demand, as well as for stamps payable on their bills of exchange: It shall be lawful for the Commissioners of Her Majesty's Treasury for the time being, or any three of them, and they are hereby authorized and empowered to compound and agree with the said governor and company of the bank of *Scotland*, and the royal bank of *Scotland*, and the *British* linen company in *Scotland*, and all or any other bankers in *Scotland*, or elsewhere, respectively, for a composition in lieu of the stamp duties payable on the promissory notes of the said banks and bankers respectively payable to the bearer on demand, as well for stamps payable on their bills of exchange; and such composition shall be made on such terms and conditions, and with such security for the payment of the same, and for keeping, producing, and rendering of such accounts, as the said last-mentioned commissioners may deem to be proper in that behalf; and upon such composition being entered into by such banks and bankers respectively it shall be lawful for them to

Power to Treasury to compound with bankers in Scotland for the stamp duties on their promissory notes.

issue and re-issue all notes and to draw all such bills for which such composition shall have been made on unstamped paper, anything in any act contained to the contrary notwithstanding.

Stamp duty on scrip certificates

From and after the passing of this act the following stamp duty shall be chargeable and paid; (that is to say,)

	£	s.	d.
On any scrip certificate, that is to say, any document denoting or intended to denote the right or title of the holder thereof or any person to any share or shares in any joint stock or other company, or proposed or intended company, or any certificate declaring or entitling the holder thereof or any person to be or become the proprietor of any share or shares of or in any such company, where such certificate or the right or title to such share or shares shall be or be intended to be transferable by the delivery of such certificate, or otherwise than by deed or instrument in writing .	0	0	1

Receipts for land or assessed taxes or Income Tax exempt from stamp duty.

No receipt given for any sum or sums of money received for or on account of land tax, or the duties of assessed taxes, or the duties on profits arising from property, professions, trades, and offices, by any collecter or receiver of such taxes or duties, or by any person having authority to collect or receive the same, shall be subject or liable to any stamp duty.

Stamps denoting the duty on policies of life assurance may be impressed or affixed.

The duties granted by an act of the present Session of Parliament on policies of assurance may be denoted either by a stamp impressed upon the paper whereon any such instrument is written, or by an adhesive stamp affixed thereto, and the Commissioners of Inland Revenue shall provide stamps of both descriptions for the purpose of denoting the said duties.

Certain particulars to be written on adhesive stamps for policies.

The adhesive stamps to be so provided for the purpose aforesaid shall be adapted for the writing of the following particulars thereon; (that is to say,) the date and number of the policy, and the names of the person insured and of one of the directors of the assurance company, or other person by whom the same shall be signed; and where an adhesive stamp shall be used or intended to be used for or upon any such policy, such stamp shall be firmly and securely affixed and made to adhere to such policy, and all the several particulars aforesaid shall be fairly and distinctly written upon such stamp at or before the time of the signing thereof by such director or other person aforesaid, or in default thereof such director or other person signing such policy shall forfeit the sum of Fifty Pounds.

The Schedule referred to by this Act.

	Duty. £	s.	d.
Articles of Clerkship or contract, whereby any person shall first become bound to serve as a clerk in order to his admission as an attorney or solicitor in any of Her Majesty's Courts at Westminster or in Ireland, or in order to his admission as a proctor in the High Court of Admiralty in England, or the Court of Admiralty in Ireland, or in any of the Ecclesiastical Courts in Doctors Commons or in Ireland . . .	80	0	0
Certificate to be taken out yearly by every person admitted as an attorney or solicitor in any of Her Majesty's Courts at Westminster or in Ireland, or in any other court in England holding pleas where the debt			

	Duty. £ s. d.
or damage amounts to forty shillings; and by every person admitted as a writer to the signet, or as a solicitor, agent, attorney, or procurator in any of the courts in Scotland; and by every person admitted or enrolled as a notary public in England, Scotland, or Ireland, who in his own name or in the name of any other person shall commence, prosecute, carry on, or defend any action, suit, prosecution, or other proceeding in any of the courts aforesaid, or do any notarial act whatever, for or in expectation of any fee, gain, or reward, as an attorney, solicitor, agent, proctor, procurator, or notary public, although not admitted or enrolled as such;	
If he shall reside within the distance of ten miles from the General Post Office in the city of London, or within the city or shire of Edinburgh, or in the city of Dublin, or within three miles thereof;	
And if he shall have been admitted for the space of three years or upwards	9 0 0
Or if he shall not have been admitted so long	4 10 0
If he shall reside elsewhere, and if he shall have been admitted for the space of three years and upwards . . .	6 0 0
Or if he shall not have been admitted so long	3 0 0
Certificate to be taken out yearly by every person being a member of one of the Four Inns of Court in England, and by every person in Ireland who in the character of conveyancer, special pleader, draftsman in equity or otherwise, shall, for or in expectation of any fee, gain, or reward, draw or prepare any conveyance of or deed or instrument relating to any estate or property, real or personal, or any other deed or contract whatever, or any pleadings or proceedings in any court of law or equity;	
If he shall reside within the distance of ten miles from the General Post Office in the city of London, or in the city of Dublin, or within three miles thereof	9 0 0
And if he shall reside elsewhere	6 0 0
Conveyance of any kind or description whatsoever, in England or Ireland, and charter disposition or contract containing the first original constitution of Feu and Ground Annual Rights in Scotland (not being a lease or tack for years), in consideration of any annual sum payable in perpetuity, or for any indefinite period, whether fee farm or other rent, feu duty, ground annual, or otherwise:	
Where the annual sum thereby reserved, secured, or made payable shall not exceed 20*s.*	0 2 6
And where the same shall exceed 20*s.* and shall not exceed 12*l.* then for every 20*s.* or any fractional part of 20*s.* of such annual sum	0 2 6
And where the same shall exceed 12*l.* and shall not exceed 24*l.*, then for every 40*s.* and for any fractional part of 40*s.* of such annual sum	0 5 0
And where the same shall exceed 24*l.* then for every 4*l.* and for any fractional part of 4*l.* of such annual sum	0 10 0

AN ACT TO ALTER CERTAIN DUTIES OF CUSTOMS.

Duties now chargeable on undermentioned Articles to cease, and following duties to be charged.

The Duties of Customs now chargeable on the articles undermentioned imported into *Scotland* and *Ireland* shall cease and determine, and in lieu thereof the following duties shall be charged from and after the twenty-first day of *April* One thousand eight hundred and fifty-three; viz.

	£	s.	d.
Spirits or strong waters, for every gallon of such spirits or strong waters, of any strength not exceeding the strength of proof by Sykes's Hydrometer, and so in proportion for any greater or less strength than the strength of proof and for any greater or less quantity than a gallon, viz.			
——— Spirits or strong waters, the produce of any British possession in America, not being sweetened spirits or spirits mixed with any article, so that the degree of strength thereof cannot be exactly ascertained by such hydrometer:			
If imported into Scotland . . . the gallon	0	5	0
——— Ireland . . . the gallon	0	3	8
——— Rum, the produce of any British possession within the limits of the East India Company's charter, not being sweetened spirits or spirits so mixed as aforesaid, in regard to which the conditions of the Act 4 Victoria, Chapter 8, have or shall have been fulfilled:			
If imported into Scotland . . . the gallon	0	5	0
——— Ireland . . . the gallon	0	3	8
——— Rum shrub, however sweeted, the produce of and imported from such possessions, in regard to which the conditions of the Act 4 Victoria, chapter 8, have or shall have been fulfilled, or the produce of and imported from any British possession in America:			
If imported into Scotland . . . the gallon	0	5	0
——— Ireland . . . the gallon	0	3	8

Duties chargeable on goods, &c. hereafter mentioned imported into united kingdom to cease on June 1, 1853.

The duties of customs chargeable upon the goods, wares, and merchandise hereafter mentioned imported into the united kingdom shall cease and determine on and after the first day of *June* one thousand eight hundred and fifty-three; viz.

Agates or cornelians, cut or manufactured; albumen; amber, manufactures of, not enumerated; anchovies; aquafortis; bandstring twist; barytes, sulphate of, ground; bast ropes, twines, and strands; blacking; books being of editions printed prior to the year 1801, bound or unbound; bran; brass, powder of; bricks and clinkers, Dutch and other sorts; bronze powder; brushes, paint; buttons of metal and other sorts; cameos, not set; camphor, refined; cantharides; carmine; carriages of all sorts; casks, empty; catlings; chalk, prepared or manufactured, and not otherwise enumerated; cider; citron, preserved in salt; cobalt, oxide of; corks, fishermen's; crayons; crystals, cut or manufactured; cucumbers preserved in salt; elder flower water; extract of chesnut bark and wood; quercitron bark; logwood; safflower. Fish, viz.: eels, turbots, of foreign taking, oysters, salmon, soles, turtle, fresh, not otherwise enumerated; cured, not otherwise enumerated; frames for pictures, prints, drawings, or mirrors; furniture woods, excepting ash, beech, birch, elm, oak, wainscot; gauze of thread; gold, leaves of; gunpowder; hair, manufactures of hair or goat's wool, or of hair or goat's wool, and any other material not particularly enumerated or otherwise charged with duty; hams of all kinds; harp strings or lute strings, silverved; honey; ink, Indian; iron wire; rough castings; isinglass; latten wire; mead or metheglin; meat, preserved in any other manner than salted; mercury, prepared; metal, leaf metal; naptha; oil of resin; olives; orange flower water; orsedew; painters colours, manufactured; pencils, of slate and not of slate; perry; phosphorus; pickles, and vegetables preserved in salt; pollard; pomegranates; pots, viz: melting pots for goldsmiths, of stone; rose water; saccharum Saturni; sausages or

puddings; seed, viz.: canary, carrot, clover, grass of all sorts, leek, lucern, mustard, onion, trefoil; all other sorts, not particularly enumerated, or otherwise charged with duty; silkworm gut; skins; articles manufactured of skins or furs; smalts; spectacles; spelter or zinc, viz.: rods and oxide of; stone and slate, hewn; marble sawn into slabs, or otherwise manufactured; tamarinds; tiles; tobacco pipes, of clay; tongues; turpentine, of a greater value than 15*s.* per cwt.; oil or spirit of; twine; vanelloes; varnish, not otherwise described; verdigris; wafers, wax, sealing; whipcord; waste wood, viz.: billet wood or brush wood, used for the purpose of stowage; yarn of silk and worsted, spun together and not dyed; raw worsted yarn not dyed, or only partially dyed, and not being fit or proper for embroidering, or other fancy purposes.

In lieu of the Duties of Customs now chargeable on tea imported into the United Kingdom, the following duties shall be charged on and after the first day of *June* one thousand eight hundred and fifty-three:

To 5th April 1854 inclusive.	From and after 5th April 1854 to 5th April 1855 inclusive.	From and after 5th April 1855 to 5th April 1856 inclusive.	From and after 5th April 1856
£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d*	£ *s.* *d.*
0 1 10	0 1 6	0 1 3	0 1 0
per Pound.	per Pound	per Pound.	per Pound.

The Duties of Customs chargeable upon the goods, wares, and merchandise hereafter mentioned imported into the United Kingdom, shall cease and determine on and after the fourth day of *June* one thousand eight hundred and fifty-three; viz.

Cables, not of iron, new and old, tarred and untarred; coir rope, twine, and strands; copper, ore of; regulus of; and brass, old, fit only to be re-manufactured; unwrought, viz.: in bricks or pigs, rose copper, and all cast copper; part wrought, viz.: in bars, rods, or ingots, hammered or raised; in plates and copper coin; or brass wire; cordage, tarred or untarred, including standing or running rigging; glass; all plate glass, cast or rolled, of whatever thickness, however small each pane, plate, or sheet, whether silvered, polished, or rough, painted or otherwise ornamented, all white flint glass bottles, not cut, engraved, or otherwise ornamented, and beads and bugles of glass; wine glasses, tumblers, and all other white flint glass goods, not cut, engraved, or otherwise ornamented; bottles of glass covered with wicker (not being cut glass), or of green or common glass; articles of green or common glass, manufactures, not otherwise enumerated or described, and old broken glass, fit only to be re-manufactured; lead, pig and sheet; linen, or linen and cotton, viz.: cambrics and lawns, commonly called French lawns, whether plain or bordered; lawns of any sort, not French; damasks and damask diaper; sails of all sorts; mats and matting; pictures; poultry and game, alive or dead; tin, viz.: in blocks, ingots, bars, or slabs; truffles; verjuice; wire, viz.: gilt, plated, silver and brass; yarn, cable yarn.

In lieu of the Duties of Customs now chargeable on the articles undermentioned imported into the United Kingdom, the following duties shall be charged on and after the fourth day of *June* one thousand eight hundred and fifty-three; viz.

		£	*s.*	*d.*
Apples, raw (not of British Possessions)	the bushel	0	0	3
——— dried	the bushel	0	1	0
Butter (not of British Possessions)	the cwt.	0	5	0

		£	s.	d.
Cheese (not of British Possessions) to be charged on the landing weight	the cwt.	0	2	6
Cocoa	the lb.	0	0	1
——— Husks and shells	the lb.	0	0	0½
——— paste and chocolate	the lb.	0	0	2
Nuts, small	the bushel	0	1	0
—— walnuts	the bushel	0	1	0
Raisins	the cwt.	0	10	0
Almonds, Jordan	the cwt.	0	10	0
——— not Jordan, nor bitter	the cwt.	0	10	0
——— paste of	the lb.	0	0	2
Arrow root	the cwt.	0	0	4½
Barley, pearled	the cwt.	0	0	4½
Baskets, viz.:				
——— Baskets corresponding with the description commonly called Berlin	the cubic foot	0	0	7
——— all others	the cubic foot	0	0	2
Beads, coral	the lb.	0	1	6
——— arango, crystal, jet, and other sorts not enumerated or described	the lb.	0	0	2
Brass, manufactures of, not otherwise enumerated	the cwt.	0	10	0
Brocade of gold or silver	the lb.	0	5	0
Bronze, manufactures of, not otherwise enumerated	the cwt.	0	10	0
Candles, viz.:				
——— spermaceti	the cwt.	0	2	4
——— stearine, till the 5th of April 1858, unless the duty upon tallow shall be repealed at an earlier time, in which case this duty shall be reduced to the same rate as tallow candles	the cwt.	0	3	6
——— tallow	the cwt.	0	2	4
——— wax	the cwt.	0	2	4
Canes, viz.:				
——— walking canes or sticks, mounted, painted, or otherwise ornamented	the 100	0	6	0
——— umbrella or parasol sticks	the 100	0	3	0
Capers, including the pickle	the lb.	0	0	1½
Cards, viz., playing cards	the dozen packs	0	15	0
Cassava powder	the cwt.	0	0	4½
Cassia lignea	the lb.	0	0	1
Chicory, or other vegetable matter applicable to the uses of chicory or coffee, viz.:				
——— raw or kiln-dried, until 10th October 1854 inclusive,	the cwt.	0	4	0
from and after 10th October 1854		Free.		
——— roasted or ground	the lb.	0	0	4
China ware, or porcelain, painted or plain, gilt or ornamented,	the cwt.	0	10	0
Cinnamon	the lb.	0	0	2
Clocks, viz.:				
——— not exceeding the value of 5*s.* each	the dozen	0	4	0
——— exceeding the value of 5*s.* and not exceeding the value of 12*s.* 6*d.* each	the dozen	0	8	0
——— exceeding the value of 12*s.* 6*d.* and not exceeding the value of 3*l.* each	each	0	2	0
——— exceeding the value of 3*l.* and not exceeding the value of 10*l.* each	each	0	4	0
——— exceeding the value of 10*l.* each	each	0	10	0
Cloves	the lb.	0	0	2
Coculus Indicus	the cwt.	0	5	0
Coffee, roasted or ground	the lb.	0	0	4

		£	s.	d.
Comfits, dry, until 5th July 1854 inclusive	the lb.	0	0	2
——— from and after 5th July 1854	the lb.	0	0	1½
Confectionery, until 5th July 1854 inclusive	the lb.	0	0	2
——— from and after 5th July 1854	the lb.	0	0	1½
Copper, manufactures of, not otherwise enumerated or described, and copper plates, engraved	the cwt.	0	10	0
Corks, ready made	the lb.	0	0	6
——— squared for rounding	the cwt.	0	8	0
Dates	the cwt.	0	10	0
Dice	the pair	1	1	0
Earthenware not otherwise enumerated or described	the cwt.	0	10	0
Feathers, dressed, viz.:				
——— ostrich	the lb.	0	3	0
——— paddy bird	the lb.	0	3	0
——— not otherwise enumerated or described	the lb.	0	3	0
Flowers, artificial, not made of silk, per cubic foot as packed, no allowance for vacant spaces	the cubic foot	0	12	0
——— wholly or in part made of silk	the cubic foot	0	12	0
Fruit, raw, not otherwise enumerated	the bushel	0	0	2
Ginger, preserved, until 5th July 1354 inclusive	the lb.	0	0	2
——— from and after 5th July 1854	the lb.	0	0	1½
Glass, viz :				
——— any kind of window glass, white or stained of one colour only, (except plate or rolled glass,) and shades and cylinders, until 5th April 1855 inclusive	the cwt.	0	2	6
———from & after 5th April 1855 until 5th April 1857 inclusive	the cwt.	0	1	6
——— from and after 5th April 1857		Free.		
——— all flint cut glass, flint coloured glass, and fancy ornamental glass, of whatever kind	the cwt.	0	10	0
Grapes	the bushel	0	0	2
Hair articles; manufactures of hair or goat's wool, or of hair or goat's wool and any other material, wholly or in part made up, not particularly enumerated or otherwise charged with duty	for every 100*l.* value	5	0	0
Hats or bonnets, viz.:				
——— of chip	the lb.	0	2	6
——— of bast, cane, or horse-hair	the lb.	0	2	6
——— of straw	the lb.	0	2	6
——— of felt, hair, wool, or beaver	each	0	1	0
Hats of silk or silk shag laid upon felt, linen, or other material,	each	0	1	0
Iron and steel, wrought or manufactured, viz.:				
——— machinery, wrought castings, tools, cutlery, and other manufactures of iron and steel, not enumerated	the cwt.	0	2	6
——— fancy ornamental articles of iron	the cwt.	0	15	0
——— ——— of steel	the cwt.	0	15	0
Jewels, emeralds, and all other precious stones, set, for every 100*l.* value		10	0	0
Lead, manufactures of, not otherwise enumerated	the cwt.	0	2	0
Leather, viz.: boot backs	the dozen pairs	0	1	6
——— cut into shapes	the cwt.	0	10	0
Liquorice paste (not of British Possessions)	the cwt.	1	0	0
——— powder (not of British Possessions)	the cwt.	1	0	0
——— root, until 5th April 1857 inclusive	the cwt.	0	5	0
——— from and after 5th April 1857		Free.		
Maccaroni	the cwt.	0	1	0
Mace	the lb.	0	1	0
Marmalade, until 5th July 1854 inclusive	the lb.	0	0	2
——— from and after 5th July 1854	the lb.	0	0	1½
Medlars	the bushel	0	0	2

		£	s.	d.
Musical instruments, viz.:				
——— boxes, small, not exceeding four inches in length,	the air	0	0	3
——— ——— large	the air	0	0	8
——— ——— overtures, or extra accompaniments	the air	0	2	6
——— piano fortes, horizontal grand . . .	each	3	0	0
——— ——— upright or square . . .	each	2	0	0
——— harmoniums or seraphines, not exceeding three stops,	each	0	12	0
——— ——— four stops, and not exceeding seven stops . .	each	1	4	0
——— ——— eight stops, and not exceeding eleven stops . .	each	1	10	0
——— ——— exceeding eleven stops	each	2	0	0
——— accordions, commonly called Chinese .	the 100 notes	0	1	0
——— ——— other sorts, including flutinas and common German square concertinas,	the 100 notes	0	5	0
——— concertina of octagon form, not common German,	each	0	4	0
——— brass instruments, all sorts . . .	the lb.	0	0	9
——— instruments, not otherwise enumerated or described, for every 100*l.* value		10	0	0
Mustard flour	the cwt.	0	1	6
Nutmegs, except those commonly called wild . .	the lb.	0	1	0
Nux vomica	the cwt.	0	2	0
Oil, viz.:				
—— almond	the lb.	0	0	1
—— bays	the lb.	0	0	1
—— essential oil of cloves	the lb.	0	1	0
Onions	the bushel	0	0	1
Pears, raw	the bushel	0	0	3
——— dried	the bushel	0	1	0
Percussion caps	the 1,000	0	0	1
Perfumery, not otherwise enumerated, and scented or fancy soap	the lb.	0	0	2
Pewter, manufactures of, not otherwise enumerated .	the cwt.	0	2	0
Pickles preserved in vinegar	the gallon	0	0	1
Pimento	the cwt.	0	5	0
Plate of gold	the oz. troy	1	1	0
—— of silver, gilt or ungilt	the oz. troy	0	1	8
Platting, or other manufactures of straw, chip, or other materials to be used in or proper for making or ornamenting hats or bonnets, not otherwise enumerated or charged with duty .	the lb.	0	2	0
——— cordonet, single, and twist of straw, or of other materials,	the lb.	0	0	6
——— willow squares	the dozen	0	0	1
Plums, commonly called French plums and prunellos .	the cwt.	0	15	0
——— dried or preserved (except in sugar), not otherwise described,	the cwt.	0	15	0
——— preserved in sugar, until 5th July 1854 inclusive,	the lb.	0	0	2
——— from and after 5th July 1854 . . .	the lb.	0	0	1½
Pomatum	the lb.	0	0	2
Potato flour	the cwt.	0	0	4½
Powder, viz.:				
——— hair powder	the lb.	0	0	2
——— perfumed	the lb.	0	0	2
——— not otherwise enumerated or described, that will serve the same purpose as starch	the cwt.	0	0	4½
Prints and drawings, plain or coloured, single .	the lb.	0	0	3
——— ——— bound or sewn . . .	the lb.	0	0	3
——— ——— admitted under treaties of international copyright, single	the lb.	0	0	1½
——— ——— bound or sewn . . .	the lb.	0	0	1½

		£	s.	d.
Quassia	the cwt.	0	1	0
Quinces	the bushel	0	0	3
Rice, not rough, nor in the husk	the cwt.	0	0	4½
—— rough, and in the husk	the quarter	0	0	9
Sago	the cwt.	0	0	4½
Scaleboard	the cwt.	0	1	0
Semolina	the cwt.	0	0	4½
Ships, foreign ships, to be broken up, with their tackle, apparel and furniture (except sails),	for every 100*l.* value	5	0	0
—— broken up	for every 100*l.* value	5	0	0
Spa ware	the cubic foot	0	0	6
Spelter or Zinc, manufactures of, not otherwise enumerated,	the cwt.	0	2	0
Spirits, cordials, or strong waters, not being the produce of any British Possession in America, nor of any British Possession within the limits of the East India Company's Charter, in regard to which the conditions of the Act 4 Vict. cap. 8 have or shall been fulfilled, sweetened or mixed with any article so that the degree of strength cannot be exactly ascertained by Sykes's hydrometer, and perfumed spirits to be used as perfumery only,	the gallon	1	0	0
Starch	the cwt.	0	0	4½
—— Gum of, torrified or calcined	the cwt.	0	0	4½
Succades, including all fruits and vegetables preserved in sugar, until the 5th July 1854 inclusive	the lb.	0	0	2
From and after the 5th July 1854	the lb.	0	0	1½
Tapioca	the cwt.	0	0	4½
Tin foil	the cwt.	0	10	0
Manufactures of tin, and not otherwise enumerated,	the cwt.	0	10	0
Toys, viz.:				
—— marbles	the cwt.	0	1	0
—— all other toys	the cubic foot	0	0	4
Turnery, not otherwise described	the cubic foot	0	0	4
Varnish, containing any quantity of alcohol or spirit	the gallon	0	12	0
Vermicelli	the cwt.	0	1	0
Vinegar	the gallon	0	0	3
Washing balls	the lb.	0	0	2
Water, Cologne water, the flask (thirty of such flasks containing not more than one gallon)	each	0	0	8
—— when not in flasks (as perfumed spirits)	the gallon	1	0	0

In lieu of the present *ad valorem* rates of duties of customs charged upon the importation into the United Kingdom of the undermentioned articles as not being enumerated in the Tariff, the following duties of customs shall be charged thereon on and after the fourth day of *June* one thousand eight hundred and fifty-three; viz.

Biscuit and bread	the cwt.	0	0	4½
Caoutchouc or Indian rubber, manufactures of	the lb.	0	0	4
Coral negligées	the lb.	0	1	0
Daguerreotype plates	the lb.	0	0	3
Fig cake	the cwt.	0	15	0
Gutta percha, manufactures of, not moulded, such as bands, sheets, soles, tubing	the cwt.	0	5	0
—— articles moulded	the lb.	0	0	2
Lucifers of wood in boxes containing not more than 100 matches,	the gross of boxes	0	0	2
—— in boxes containing more than 100 matches,	the gross of boxes	0	0	3
—— vesta of wax, in boxes not exceeding 1,000 matches,	the dozen boxes	0	0	6

		£	s.	d.
Lucifers in boxes exceeding 1000 matches	the 1000 matches	0	0	0½
Mandioca flour	the cwt.	0	0	4½
Manna croup	the cwt.	0	0	4½
Mustard, mixed or manufactured, except flour	the cwt.	0	5	0
Oil cloth, for table covers	the square yard	0	0	1
Salacine	the oz.	0	0	3
Sauces, not otherwise enumerated	the lb.	0	0	1
Soy	the gallon	0	0	6
Sterine, till the 5th April 1858, unless the duty upon tallow shall be repealed at an earlier time, in which case this duty shall then cease,	the cwt.	0	3	6
After the 5th April 1858		Free.		
Veneers	the cwt.	0	1	0

In lieu of the duties of customs now chargeable on the article undermentioned imported into the United Kingdom, the following duties shall be charged on and after the eighth day of *June* one thousand eight hundred and fifty-three; viz.

Eggs not of British Possessions	the 120	0	0	4

In lieu of the duties of customs now chargeable on the articles undermentioned imported into the United Kingdom, the following duties shall be charged on and after the twelfth day of *July* one thousand eight hundred and fifty-three; viz.

Soap, not being scented or fancy, viz.:				
——— hard	the cwt.	0	0	8
——— soft	the cwt.	7	0	8
——— Naples	the cwt.	0	0	8

In lieu of the duties of customs now chargeable on the articles undermentioned imported into the United Kingdom, the following duties shall be charged on and after the eleventh day of *June* one thousand eight hundred and fifty-three; viz.

Oranges and lemons	the bushel	0	0	8
Books, being bound in editions printed in or since the year 1801, bound or unbound	the cwt.	1	10	0
——— admited under treaties of international copyright, or if of and from a British Possession	the cwt.	0	15	0
Cherries, raw	the bushel	0	0	2
——— dried, until 5th July 1854 inclusive	the lb.	0	0	2
——— ditto, from and after 5th July 1854	the lb.	0	0	1½
Cotton manufactures, viz.:				
——— fringe	the lb.	0	0	2
——— gloves, of cotton or thread	the dozen pairs	0	0	3
——— stockings, of cotton or thread	the dozen pairs	0	0	6
——— socks, or half hose, of cotton or thread,	the dozen pairs	0	0	3
——— articles or manufactures of cotton, wholly or in part made up, not otherwise charged with duty,	for every 100*l.* value	5	0	0
Embroidery and needlework, viz.:—				
——— silk net, figured with the needle, being imitation lace, and articles thereof	the lb.	0	10	0
——— cotton net, figured with the needle, being imitation lace, and articles thereof	the lb.	0	8	0
——— curtains, commonly called Swiss, embroidered on muslin or net,	the lb.	0	1	0
——— all other embroidery not enumerated,	for every 100*l.* value	10	0	0
——— of and from British Possessions	for every 100*l.* value	5	0	0

		£	s.	d.
Lace and articles thereof, viz.:				
——— mohair or worsted	the lb.	0	1	0
——— thread or cotton pillow lace (not being Brussels point or Saxon bone lace), not exceeding one inch in width	the lb.	1	0	0
——— thread or cotton pillow lace (not being Brussels point or Saxon bone lace), exceeding one inch in width	the lb.	2	0	0
——— silk lace, pillow and application, not being Saxon wire ground lace	the lb.	1	10	0
——— silk Saxon wire ground lace, and all lace known as Maltese,	the lb.	0	8	0
——— Brussels point, and other lace made by the hand, not otherwise charged with duty	for every 100*l.* value	10	0	0
Linen, or linen and cotton manufactures, viz.:				
——— cambric handkerchiefs, hemmed or hemstitched, not trimmed,	the dozen	0	2	6
——— stays	the dozen pairs	0	4	0
——— articles, manufactures of linen, or of linen mixed with cotton or with wool, wholly or in part made up, not particularly enumerated or otherwise chargeable with duty, for every	100*l.* value	5	0	0
Mill boards	the lb.	0	0	2½
Paper, viz.:				
——— brown paper made of old rope or cordage only, without separating or extracting the pitch or tar therefrom, and without any mixture of other materials therewith	the lb.	0	0	2½
——— printed, painted, or stained paper or paper-hangings, or flock paper	the square yard	0	0	1
Paper, waste paper, or paper of any other sort not particularly enumerated or described, not otherwise charged with duty,	the lb.	0	0	2½
Pasteboard	the lb.	0	0	2½
Silk manufactures, being				
——— velvet, the produce of Europe, plain or figured:				
—— broad stuffs	the lb.	0	9	0
——— the foundation of which is wholly composed of cotton or other materials than silk	the lb.	0	3	0
——— —— ribbons of velvet, or silk embossed with velvet,	the lb.	0	10	0
——— the foundation of which is wholly composed of cotton, or other materials than silk	the lb.	0	3	6
——— manufactures of silk, or of silk mixed with any other materials, the produce of Europe, called plush	the lb.	0	3	0
—— black plush, commonly used for making hats,	the lb.	0	1	0
——— parasols and umbrellas	each	0	1	0
——— damask of silk and wool or other materials, for furniture	the lb.	0	0	10
——— China	the running yard	0	0	8
——— corahs, choppahs, Bandannas, and Tussore cloths, viz.: in pieces not exceeding 5¼ yards in length,	the piece	0	0	4
exceeding 5¼ and not exceeding 6¼ yards,	the piece	0	0	6
6¼ and not exceeding 7¼ yards,	the piece	0	0	8
7¼ and not exceeding 8¼ yards,	the piece	0	0	9
8¼ and not exceeding 9¼ yards,	the piece	0	0	10
and for every additional yard in length	the yard	0	0	1½
——— China crape shawls, plain and damask	the lb.	0	3	0
——— ——————— embroidered	the lb.	0	5	0
——— Pongees, in pieces not exceeding 15 yards in length,	the piece	0	2	0
——— exceeding 15 yards and not exceeding 21 yards in length,	the piece	0	3	0
——— exceeding 21 yards and not exceeding 31 yards in length,	the piece	0	5	0

		£	s.	d.
Silk handkerchiefs, plain and figured, in pieces not exceeding 9 yards in length	the piece	0	1	6
exceeding 9 yards and not exceeding 18 yards in length,	the piece	0	3	0
Watches, of gold, silver, or other metal, exceeding the value of 10*l.* each	each	1	0	0
—— other watches, viz.:				
—— gold, open faces	each	0	5	0
—— hunters	each	0	7	6
—— repeaters	each	0	15	0
—— silver, or any other metal not gold:				
—— open faces	each	0	2	6
—— hunters	each	0	3	6
—— repeaters	each	0	8	0
Woollens, articles or manufactures of wool (not being goat's wool) or of wool mixed with cotton, viz.:				
—— carpets and rugs	the square yard	0	0	6
—— shawls, scarfs, and handkerchiefs, plain and not printed,	the lb.	0	0	4
—— printed	the lb.	0	0	8
—— gloves	the dozen pairs	0	0	3
—— articles or manufactures of wool mixed with cotton, wholly or in part made up, not otherwise charged with duty, for	every 100*l.* value	5	0	0

In lieu of the present *ad valorem* rates of duties of customs charged upon the importation into the United Kingdom of the undermentioned articles as not being enumerated in the tariff, the following duties of customs shall be charged thereon on and after the eleventh day of *June* one thousand eight hundred and fifty-three; viz.

Paper, gilt, stained, coloured, embossed, and all fancy kinds, not being paper-hangings	the lb.	0	0	2½

The duties of customs chargeable upon the goods hereafter mentioned, imported into the United Kingdom, shall cease and determine on and after the twenty-third day of *June* one thousand eight hundred and fifty-three; viz.

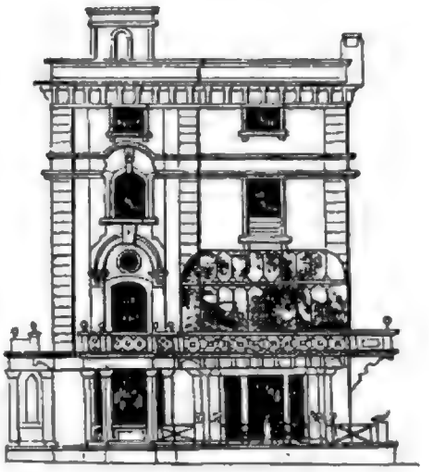
Flock for paper stainers.

On and after the fifth day of *July* one thousand eight hundred and fifty-three so much of an act passed in Session of Parliament holden in the third and fourth years of the reign of His late Majesty King *William* the Fourth, chapter one hundred and one, section three, as provides that the allowance commonly called draft, then made by the Commissioners of Excise in the weighing of tea, should be made by the Commissioners of Customs under the authority of the said act, shall be and the same is hereby repealed; and the allowance of one pound for draft on each chest of tea exceeding twenty-eight pounds in weight now made by the Commissioners of Customs under the authority of the said act shall cease and determine upon all tea which shall arrive and be reported at the custom house of any port in the United Kingdom on and after the fifth day of *July* one thousand eight hundred and fifty-three.

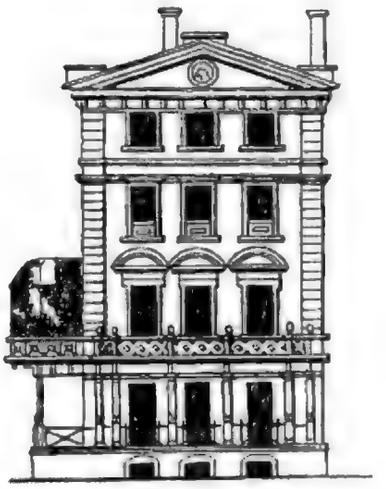
The duties imposed by this act shall be under the management of the Commissioners of Her Majesty's Customs, and shall be ascertained, raised, levied, collected, paid, recovered, and allowed, and applied or appropriated, under the provisions of any act or acts now in force or hereafter to be made relating to the customs.

HARWICH, DOVERCOURT NEW TOWN.

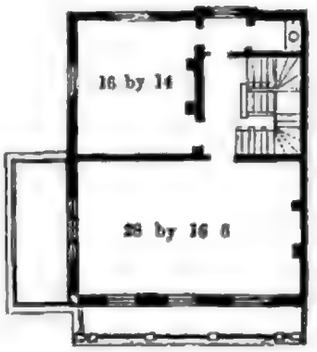
2ND CLASS.



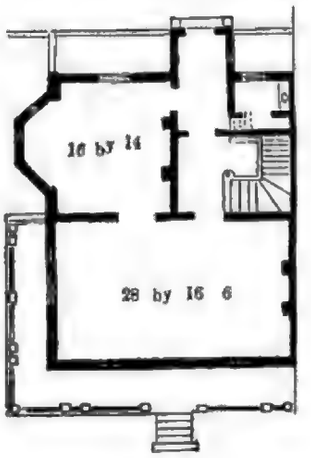
END ELEVATION.



ELEVATION NEXT GARDEN.



ONE PAIR.



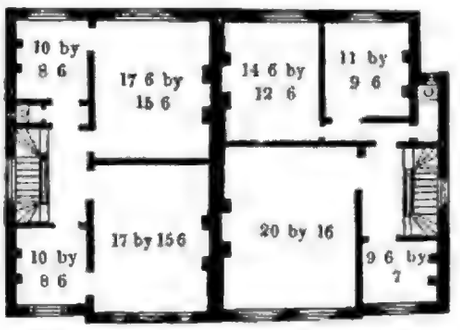
GROUND FLOOR.

ESTIMATED COST £450.

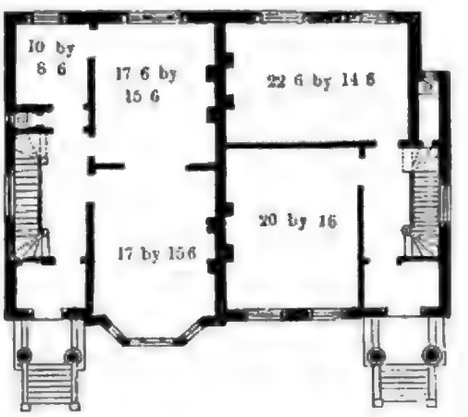
VILLAS, CARLTON ROAD, KILBURN PARK.



ELEVATION.



ONE PAIR.

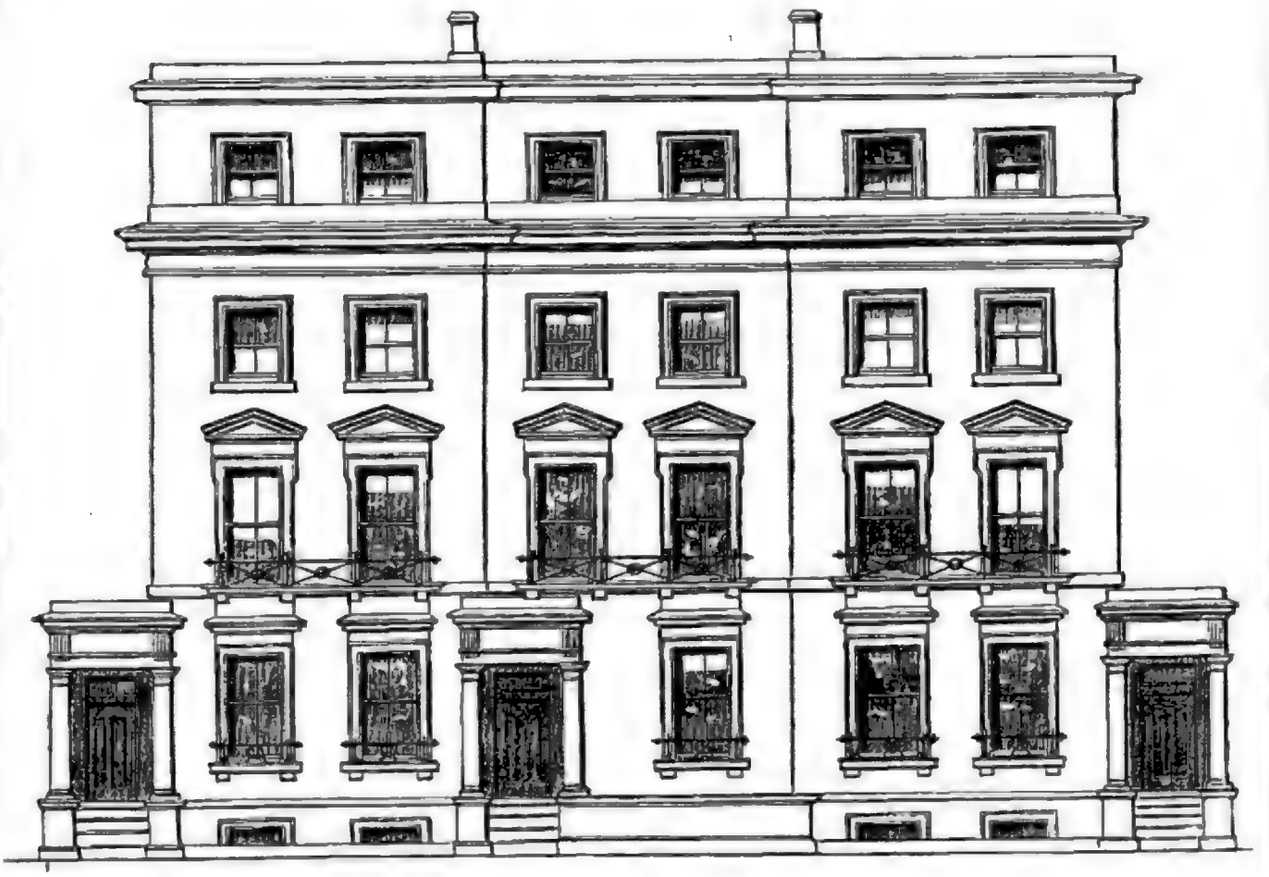


GROUND FLOOR.

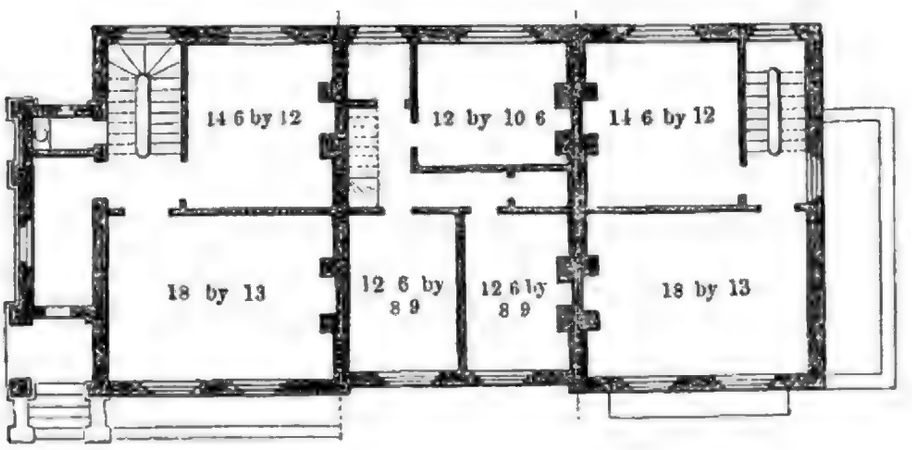
Estimated cost £850 the pair.

WESTBOURN PARK, PADDINGTON.

FULL-SIZED 3RD CLASS.



ELEVATION. 74 FEET.

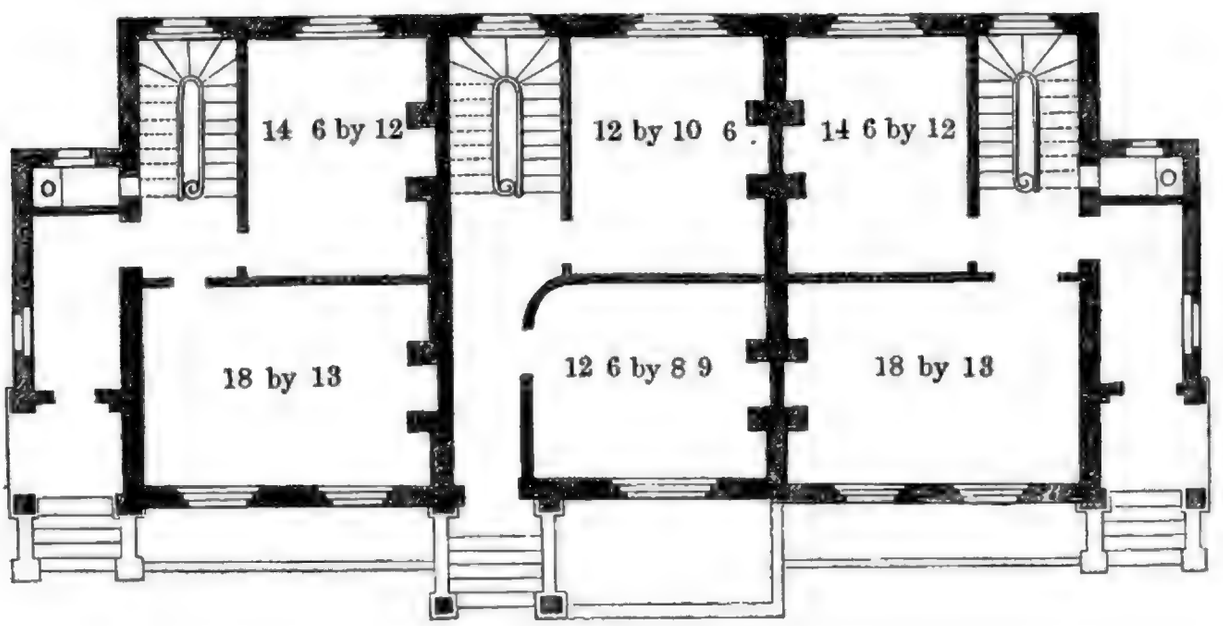


GROUND PLAN. CHAMBER PLAN. ONE PAIR.

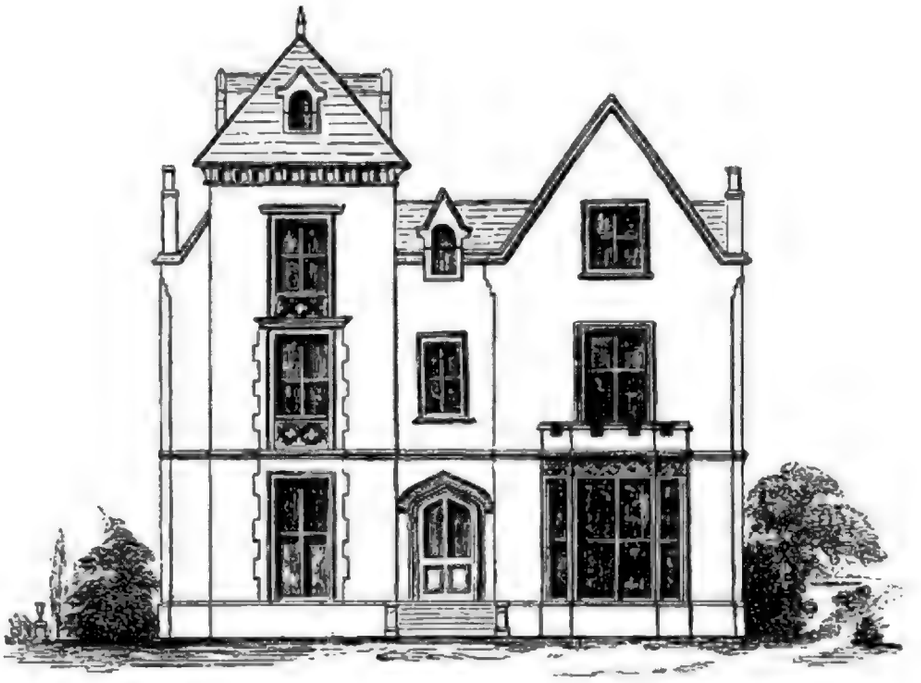
ESTIMATED COST £800 THE THREE.

[over.

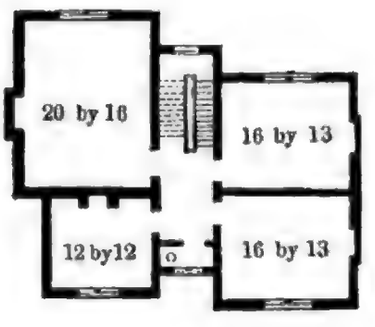
PLAN VARIED.



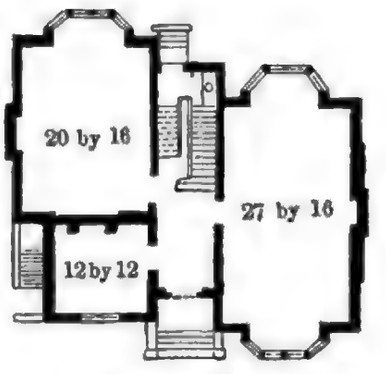
No. 2, CARLTON HILL, ST. JOHN'S WOOD.



ELEVATION.



ONE PAIR.



GROUND PLAN.

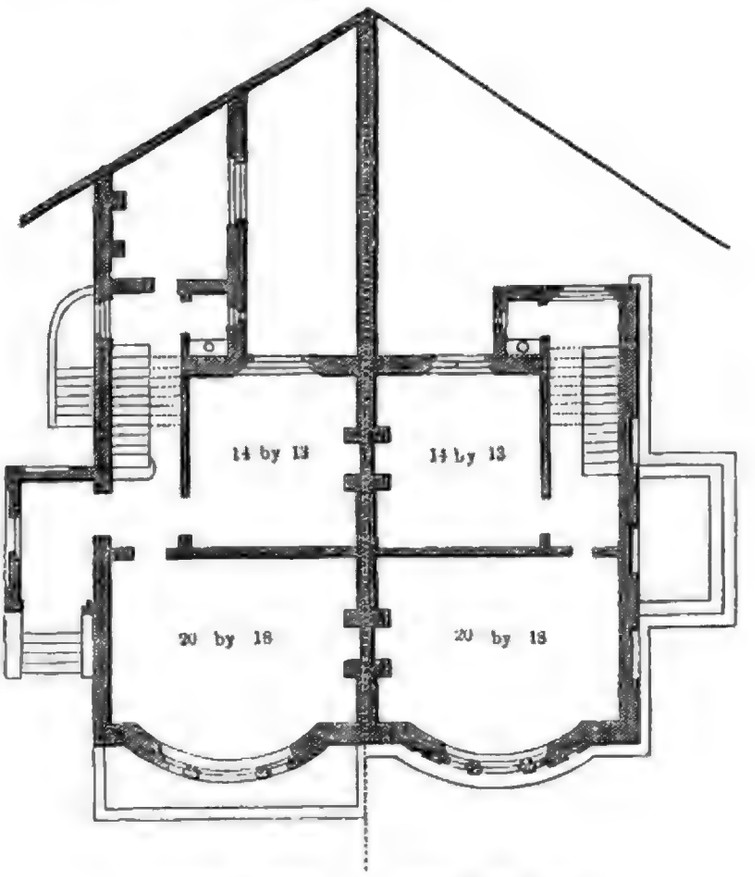
Estimated cost £475.

PADDINGTON ESTATE.

2ND CLASS.



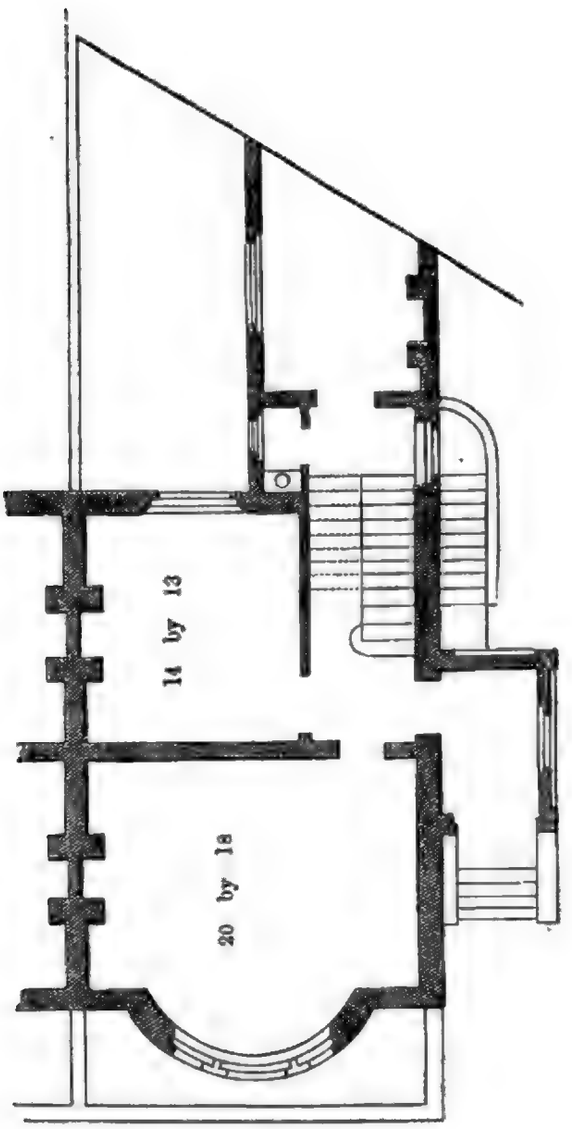
ELEVATION.



GROUND PLAN. ONE PAIR PLAN.

COST £1000 THE PAIR.

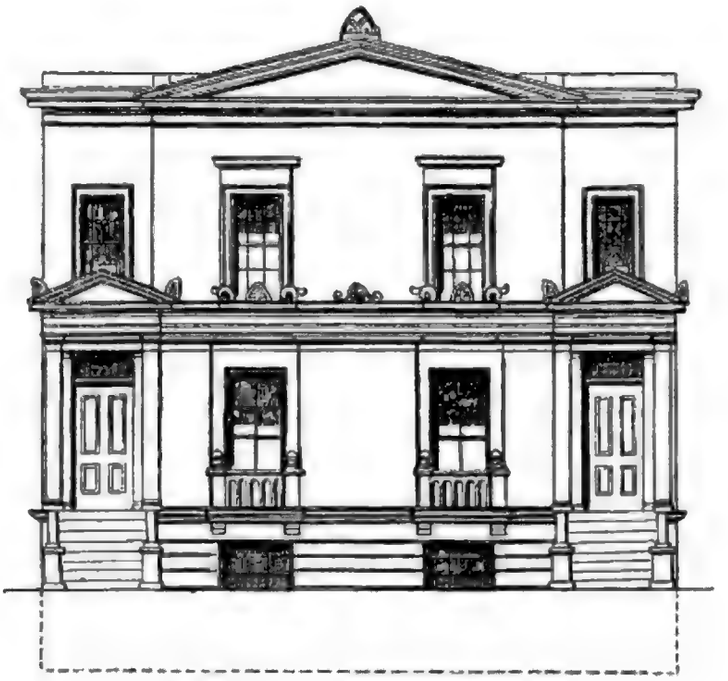
over.



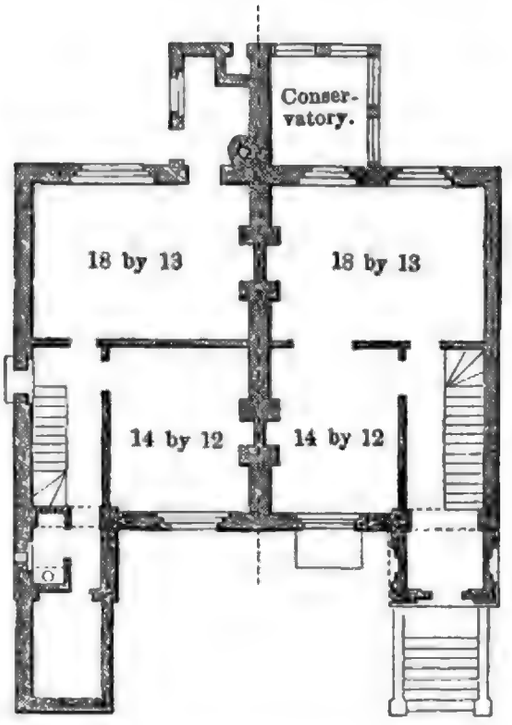
GROUND PLAN.

TORIANO AVENUE, KENTISH TOWN.

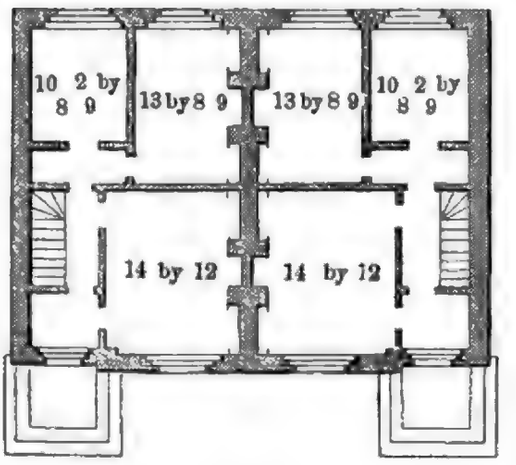
SMALL 3RD CLASS.



ELEVATION. 39 FT. 6 IN.



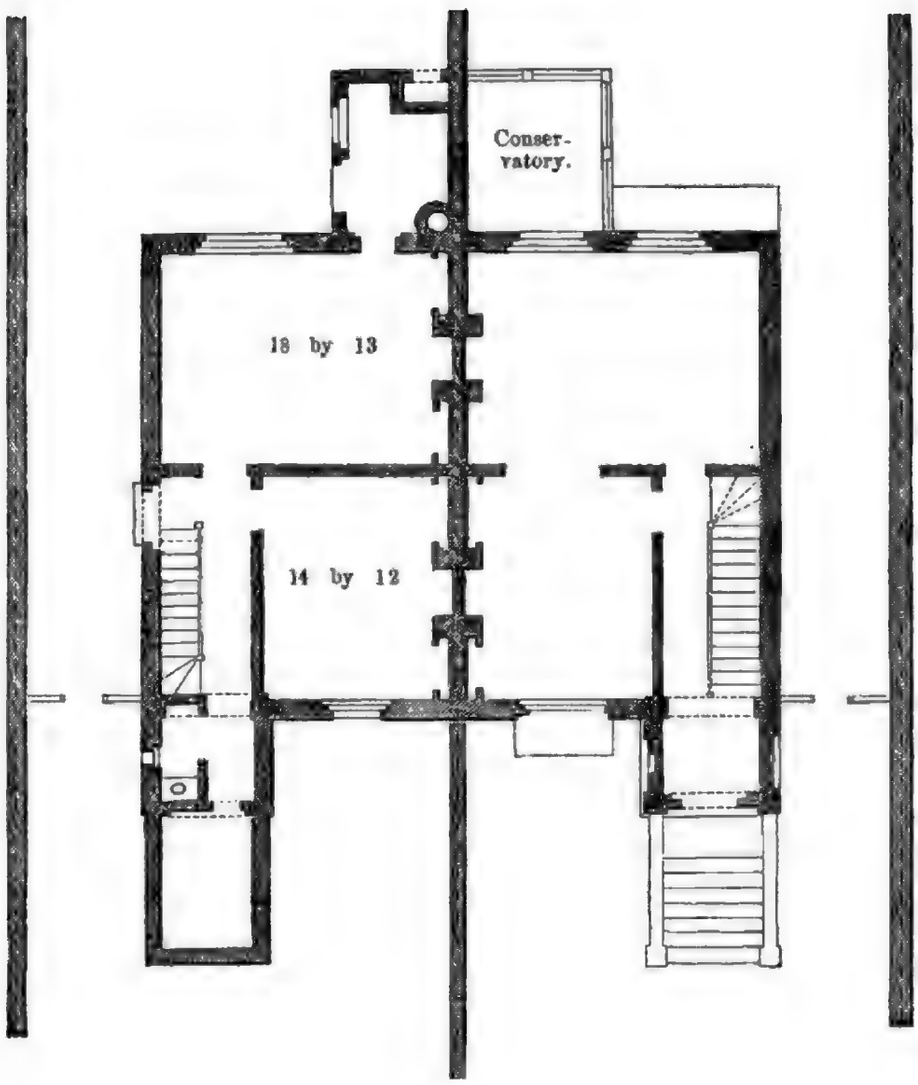
BASEMENT AND GROUND PLAN.



ONE PAIR PLAN.

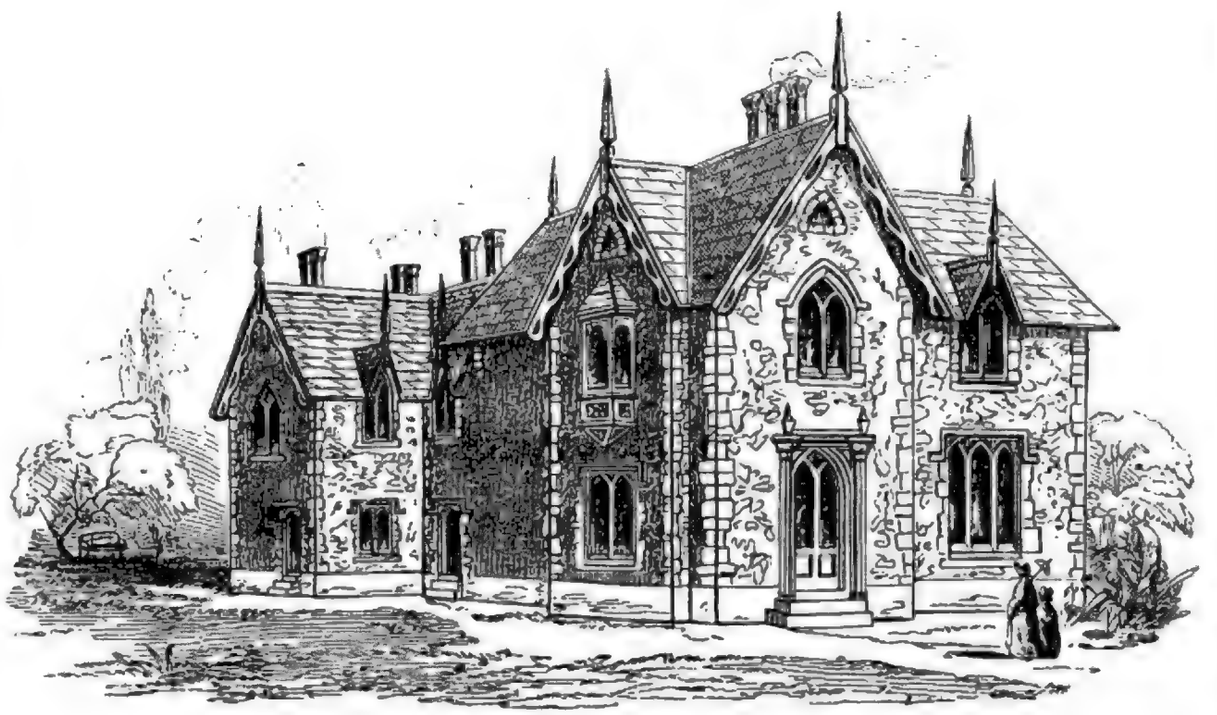
COST £500 THE PAIR.

[over.

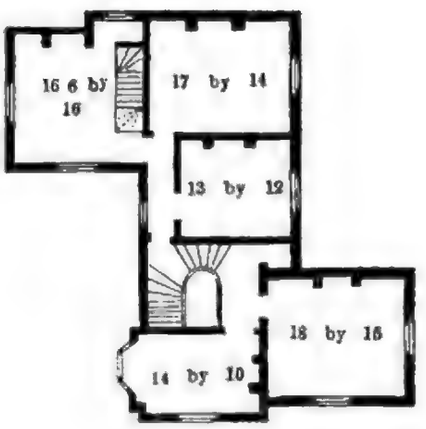


BASEMENT AND GROUND PLAN.

SAXON VILLA, CLIFTON TERRACE, BRIGHTON.



PERSPECTIVE SKETCH.



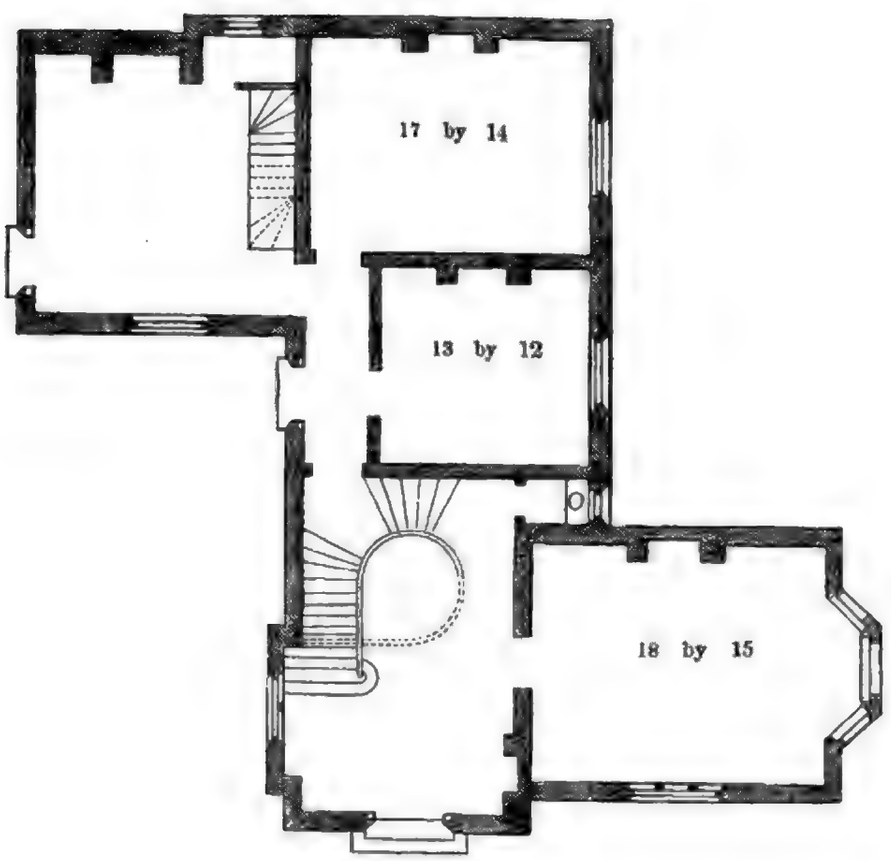
ONE PAIR.



GROUND PLAN.

ESTIMATED COST £[illegible].

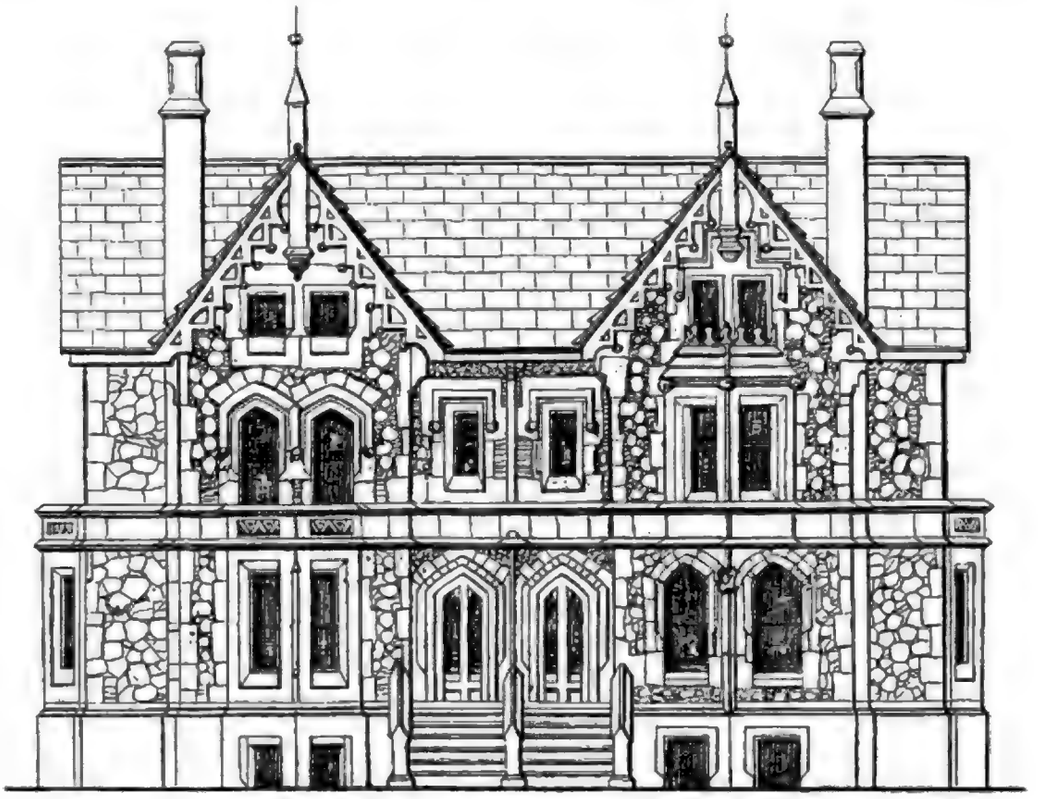
Form.



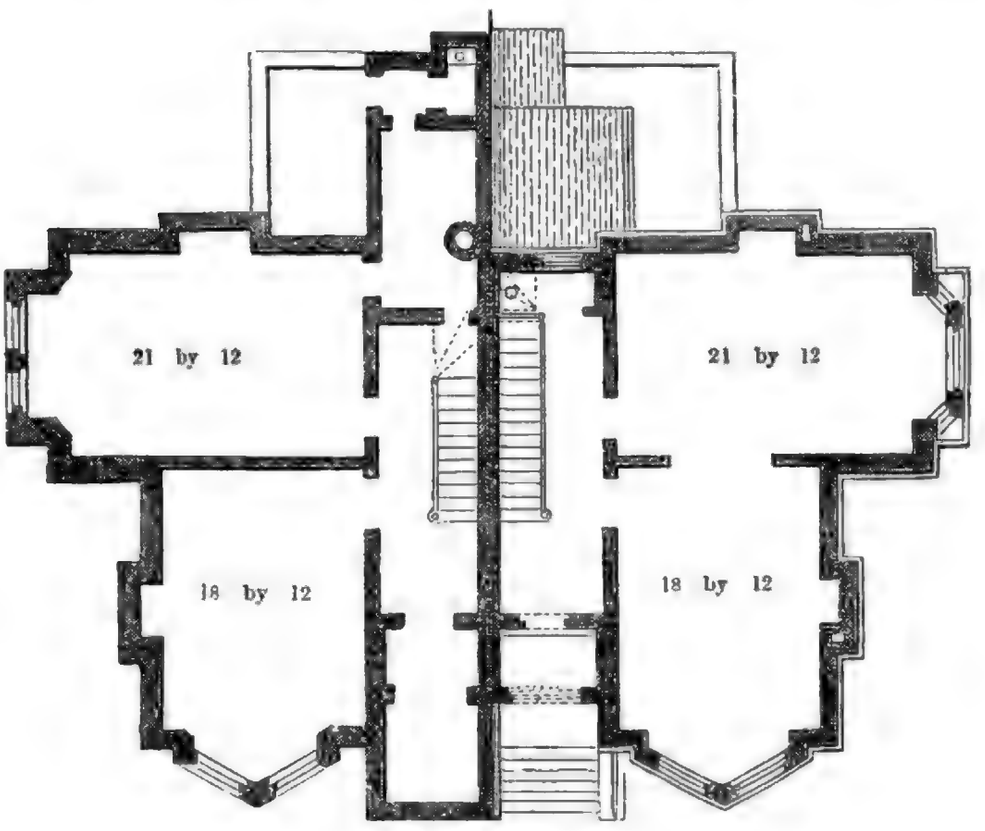
GROUND PLAN.

HARWICH, VILLAS AT DOVERCOURT NEW TOWN.

3RD CLASS.



ELEVATION.



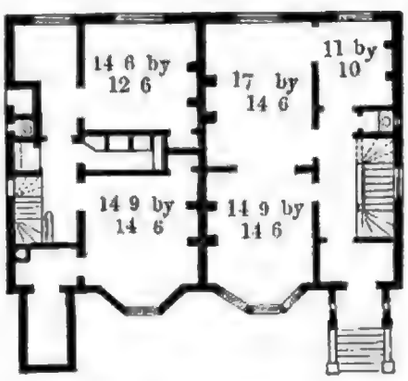
BASEMENT AND GROUND PLAN.

COST £750 THE PAIR.

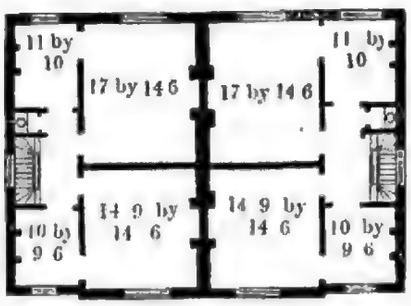
VILLAS, CARLTON ROAD, KILBURN PARK.



ELEVATION.



BASEMENT AND GROUND FLOOR.



ONE PAIR. TWO PAIR.

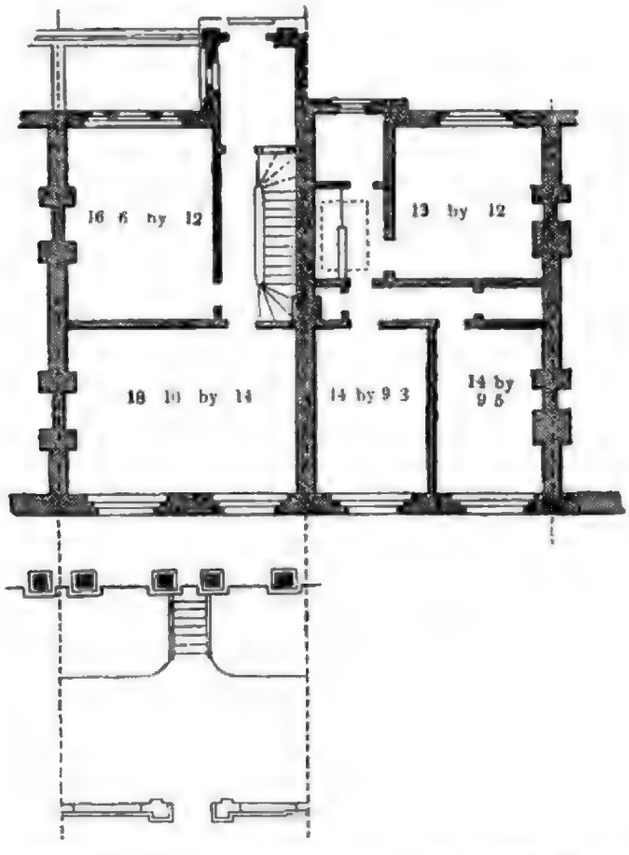
ESTIMATED COST £650 THE PAIR.

DOVERCOURT NEW TOWN, NEAR HARWICH.

GARDEN FRONT. PRINCIPAL FRONT.



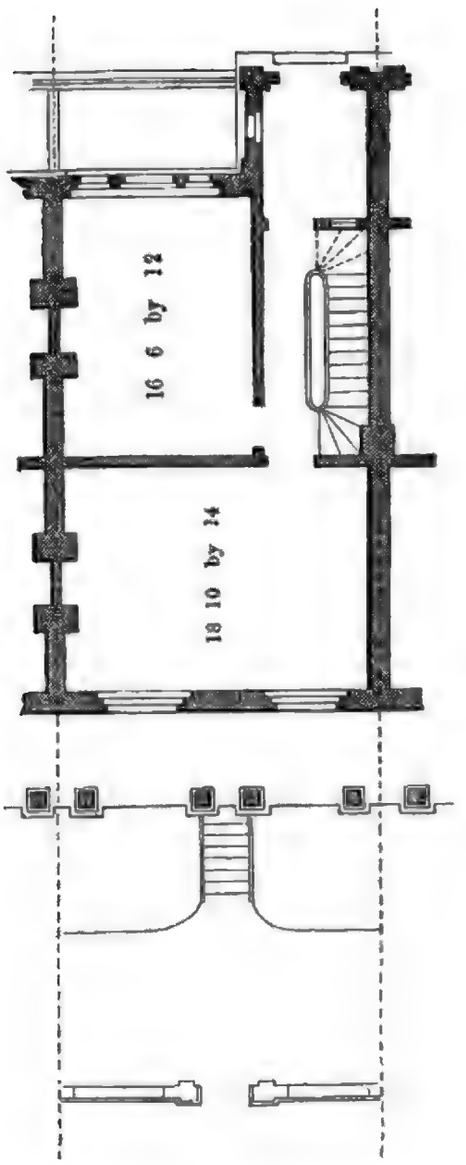
20 0 ELEVATION.



GROUND PLAN. CHAMBER PLAN.

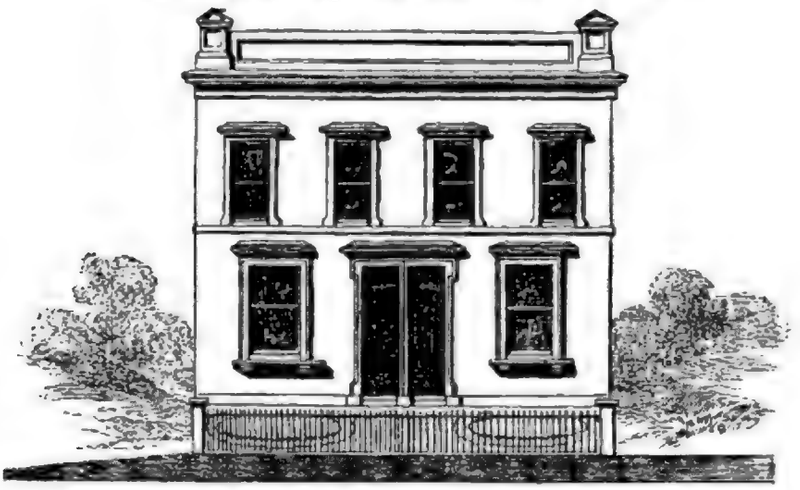
Cost £650.

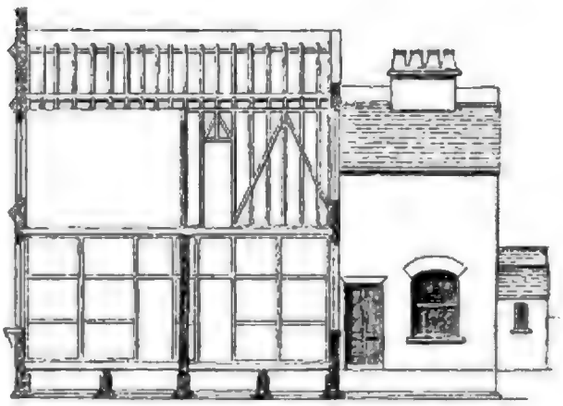
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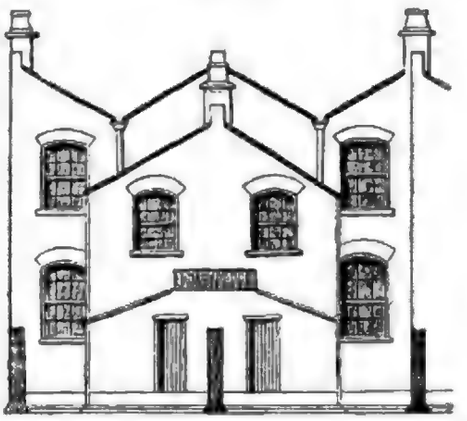


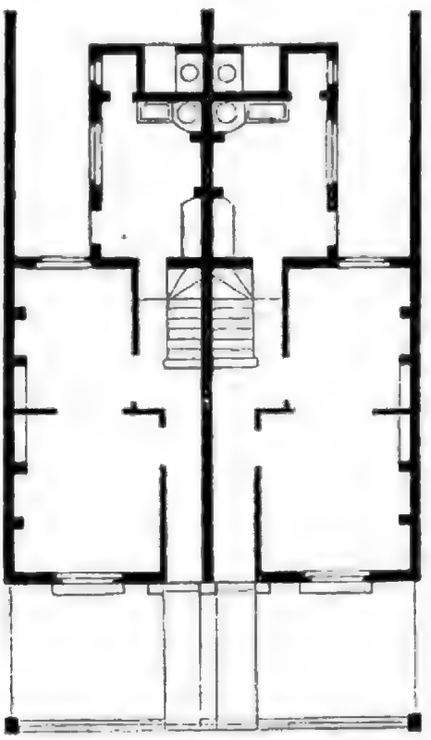
GROUND PLAN.

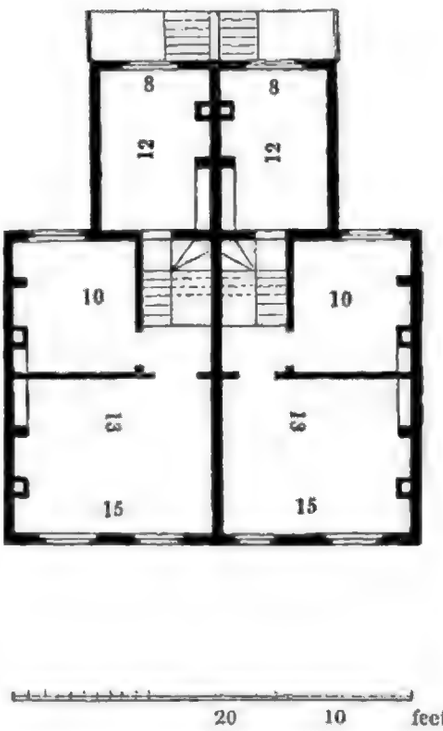
DALSTON, NEAR LONDON.









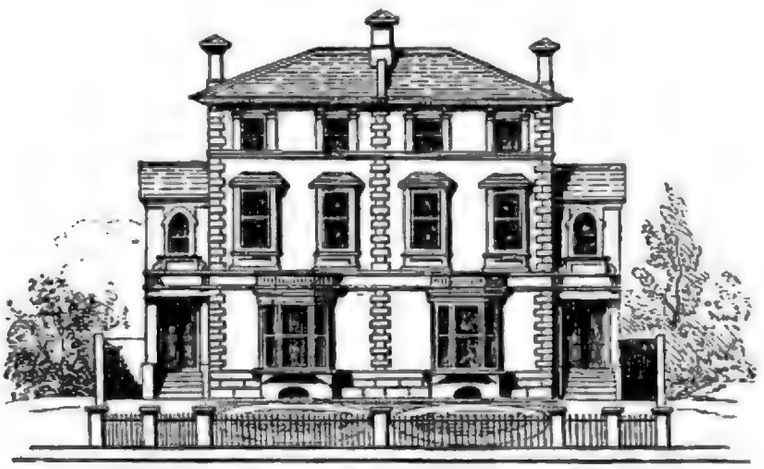


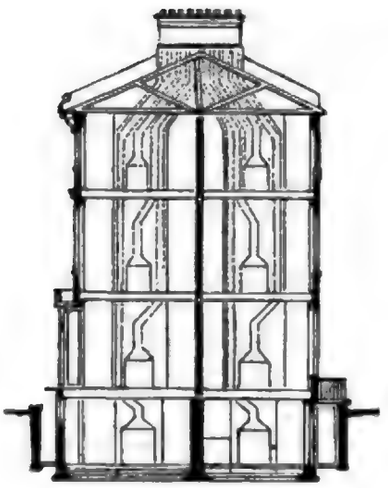
Cost £340 the pair.

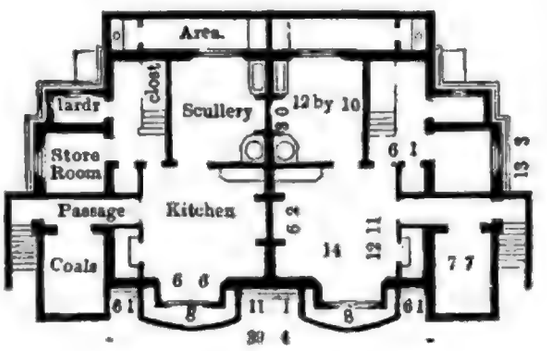
Let at £23 per Annum. Containing Six Rooms and Conveniencies.

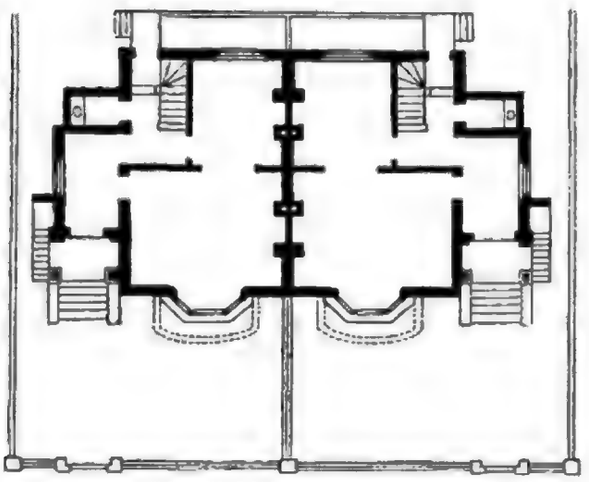
Thos. Tallock, Archt., Dalston.]

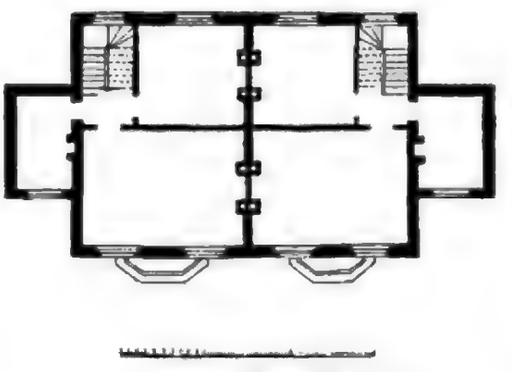
VILLAS IN REGENT'S PARK.











Contract Price £1500.

Each contains Ten Rooms, Pantry, Cellars, and Conveniencies.
Rental £75 Each.

Thos. Tallock, Archt., Dalston.]

ON LANDED PROPERTY.

CHAPTER I.

LANDLORD AND TENANT—THEIR POSITION AND CONNECTIONS.

The landlord is the owner of the soil, whose proprietorship has been derived chiefly from priority of occupation, and from the act of labour subsequently bestowed. To these rights of occupancy a tacit acknowledgment and virtual acquiescence have been yielded by the general consent of the human race. Jurists have entangled themselves in very lengthened disputations and much subtlety of argument in trying to determine whether the act of labour was necessary to support the right acquired by priority of occupation; and also, if the public assent be essential to confirm the two privileges, when joined, in constituting the ownership of property. The question has been long since settled by general opinion conferring on land the same rights as any other articles which a man can call his own; the same vested interests, and the same inalienable adjuncts. The law of civilized nations, or morality armed with power, has sanctioned the conferment, and upholds the continuance.

Right of occupancy

confirmed by law.

Land has been appropriated in order to make it more generally useful, and to create a general interest in its favour. An enlightened barbarism made the first appropriations in large grants of land as the plunder of conquest, and the reward of services, to be held in tenure for future performances and attendance. The inconvenient superintendence soon induced the dismemberment of the extensive grants; the uncertain and short-lived reigns which prevailed, caused many confiscations; and the constant wars and intestine broils of unsettled times, produced large changes in the possession of the separated portions of the grants. The no less quarrelsome leisure of peace had a large effect in leading to fines and confiscations, which still further augmented the distribution of the land as private property. When trade became flourishing, and money became abundant, land was bought and sold as any other marketable commodity, the divisions being varied chiefly by chance and accident; a large part generally remaining with the name of the original holder, and still giving the title and rank which accompanied the gift. In this way land has become the property of the present possessors, who hold by purchase, which rests on the original appropriation.

Grants and alienations of land.

Rest on appropriation.

For a very long period of time the property of land constituted almost the only form of wealth and power, and carried along with it the sole dis-

Land the distinction of society,

tinctions of society. The nobles and proprietors formed one part of the community; and retainers, dependents, and slaves, were the other portion, which was almost wholly bereft of personal liberty, and lived on the charity and pleasure of the higher grade. There was no nobility without property in land—no power, no respect, nor even the natural gift of personal freedom. Every idea was based upon the soil: all settlements and associations, isolated or collective, were founded upon the country, by which the mode of life was regulated, and the social institutions conformed. In every country where land has been appropriated, in every form of government, and under every dynasty

and its power

which has ruled on earth, in every change and revolution that has happened, and under every different phase which society has assumed, the land-owning body has ever had a preponderance in the legislation, and has directed the machinery of government. A certain prestige of independence and patriotism has always in some kind and degree been found attaching to the owners of the soil, which has not a little contributed to the essential qualification in a member of the legislature, and of the open recognition of landed property conferring a title to the distinction in that respect. The early preponderance of the owners of the soil has not been lost, and little if at all impaired by the upheaving of the other classes of society—an influence still clings to it, as compared with other kinds of property, and an earnest desire for the possession of it is

its influence and avidity of purchase,

evinced by all persons who can command the means of purchase. The durable nature of its essence forms the primary consideration, the current value may fluctuate as that of other commodities, but a total loss never can be sustained by its possession, as no evanescence takes place of the original matter. This quality confers the superiority of property in land over other inheritances, and has raised the estimation both of the article and the possessor. The detached and isolated position of the property confers a power that is of a very useful and agreeable exercise, and it affords a relaxation not enjoyed by other employments of capital and time. This leisure gives opportunity for the discharge of public duties, which interfere least with the absence from business of the habits of life which those duties occasioned and required. The business of legislation gradually fell into the hands of the party which had most leisure for the purpose, and inclination for the object. The

and changes from the social effect.

gradual increase of numbers soon acquired a preponderating force, which materially changed the original idea and constitution of the British House of Commons.

Under the gifts of feudal tenure, the possession of land was conferred on the condition of military service, and of furnishing a fixed quota of armed followers, bearing the same relation to the landlord as he did to the sovereign. Land under its feudal relations was regarded as a thing out of commerce altogether, and no idea was entertained of its being a certain amount of property appreciable at a money value. It was estimated to be an inalienable "entirety" held under the crown, and the gift and the condition

of tenure, with the concomitant obligations, passed exclusively to the eldest son, whose prior right in every affair has been recognized from the first dawn of civilization and of social arrangements. This "backbone" of feudalism has been copied into the laws of real property, as the land is termed, along with its immoveable subordinations, in contradistinction; or of personal property, which consists of moveable goods of every kind that are evanescent in quality and perishable in the nature. When the growth of towns, and the influx of money, along with other circumstances, compelled land to be an article of ordinary bargain and sale, and of conversion into money and reconversion, the custom was continued of devolving on the eldest son, the inheritance of the landed property: it was ultimately restricted by law to cases of intestacy only. This law of primogeniture has been much reviled, as "to enrich one it beggars all the rest of the children," and as making distinctions, which tend to disarrange and disunite the frame-work of society. But in the main it has been productive of much good: the landed property has been preserved in fair and suitable divisions, which uphold the influence and support the respectability: it has been kept from being partitioned in minute sub-divisions, which derange the general utility and take away the power of its own improvement by the total want of means. Feudalism saw that its purposes required the grants of land to be large rather than small, and civilization finds that to be improved and its resources developed, land must be in the hands of wealth of an amount that is able to furnish the sufficient means for that purpose, and also to make the suitable family provisions that attend the relations of human nature. In Britain, primogeniture applies in cases of intestacy only, and most completely differs from the arbitrary laws of continental Europe, which divide the land among the children, without or with the parent's consent. This compulsory partition, though seemingly founded on justice and equity, has been found very injurious to the general interest, and not very profitable to the parties themselves, who obtain shares of insufficient amount, and which must be assisted by other pursuits. The evil has been produced by an extreme of the application, which in a well-meant intenseness overlooks the contingencies that are near, and the consequences that are remote. It has been much more hurtful than the use of primogeniture, even in the opinion of its warmest admirers.

Original holding.

Primogeniture,

use and abuse of it;

differs from the law of the continent of Europe,

and less hurtful.

Land-ownership is thus privileged with the application of a law, which in cases of intestacy conveys the property intact to the eldest son, or heir-at-law, who receives the patrimony in exclusion of all other claims. It meets our approbation in so far as it preserves the land in portions sufficient to support its respect and maintain its dignity, and by which the general utility is developed, and the efficiency remains unimpaired. When divided estates of land are held in one possession, the parental judgment must exercise its discretion in devising, by will, the due bequeathments of the adequate value and amount. And if by intestacy the whole landed

property goes to primogeniture, the next revolution in the family of possession may correct the discrepancy, and modify the standard of inheritance.

Entail of land.

A stretch of primogeniture has produced the entail, by which landed property is devised by one possessor to pass for ever in one line of possession, as may be defined in the deed of settlement. It also passed free of all debts, which were obliterated on the successor receiving the property. This regulation has proved a complete snare to the commercial dealer, who was debarred from touching the property itself, and who found his claims wholly extinguished by the exchange of proprietors.

Stretch of primogeniture;

The entail of lands of a proper and moderate extent in a direct line of succession constituted no evil of itself, it was only primogeniture secured by a regulated assignment, which set aside any other intentions on that point.

annulling of debts hurtful

But very questionable was the extinction of debts of all kinds at every change of ownership, the iniquity was palpable, and the damage to society needed not any demonstration. The remedy was simple, in leaving the property to pass intact, and in the law allowing the creditor a fixed annuity till paid his claim from every successor in the property. As the entail stood, a barrier was raised against any movement on the property, no improvements could be done, nor any liability contracted. The hands of the landlord were fastened, and his willing energies rendered useless. In many cases, the difficulty of improvement lies far less in the unwillingness or ignorance

restricts improvements.

of the landowner, than in the irrelevance of the proposed advantage to his personal interests in his parental or other capacity, or in his pecuniary inability to undertake it. The landlord may be the father of a large family, all unprovided for, except the eldest son, upon whom the estate devolves, and every outlay on the land only adds to the settled inheritance, to the loss of the unportioned part of his family, or he may be a young proprietor just come into a possession burdened with jointures, mortgages, and the unpaid portions of younger brothers and sisters charged upon his estate. Debts, mortgages, and incumbrances will be incurred in the course of human transactions, and whenever a landed security can be got, an encouragement is held out to advance money upon it. It is certain

Burdens by it.

that not more than one-half the income derived from land truly belongs to its nominal owners, and the proportion has by many well-informed persons been estimated at not more than one-third. The remainder belongs chiefly to others, to mortgagees, rent-charge owners, jointresses, annuitants, and the like; while the nominal owners bear all the costs of management, and all the accidental or occasional losses which are necessarily incident to landed property, whether held beneficially or otherwise. Such cases, and others of a similar nature, form the large majority: absolute and independent ownership is a rare occurrence.

Disruptions and power to lay out money.

These impediments have been somewhat removed by the partial disruption of large entails, and by a recent act to lay out capital upon the settled estates in such a manner as to constitute

a separate investment, devolving as rent-charge upon the heir-at-law, or next in the settlement. It remains to be seen whether these measures shall prove only momentarily advantageous or permanently of the benefits that have been expected. The borrowing of capital to carry on business of any kind is not generally to be approved, and it is preferred to reduce the business to the capital. Loans of money contracted upon the provision of the principal and interest being repaid together in a fixed number of years, seem to double the evil which are intended to be modified, by encouraging a course of investment which will call for artificial aid to support it, and by strengthening and indirectly subsidising a system of family entail, as against purchasers, and thus preventing the application of free capital to the soil, which should be facilitated by every wise government.

Loans of money not advantageous,

But if there be not a sad deficiency of judgment in the application of capital in the improvement of landed property, such incumbrances and annual charges as are incurred by the government loans of money are very trifling in comparison with the quick and lasting benefits that are derived from the drainage of arable lands that are fitted to repay the cost, from the erection of suitable and well-designed farm buildings, and from the planting of waste grounds that are naturally removed beyond any species of cultivation. The two latter purposes are only in prospect, but must soon be included in the act; and though the profit of plantations be of a distant nature, it must be reckoned an application of a most suitable kind as a permanent investment. The raising of embankments and the cutting of water-courses may also be included in the provisions of the act, and thus comprehend the most obvious and tangible improvements that can be effected on land. The charge must be reckoned trifling in respect of the benefits derived, and as the tenant will assist with the draining of land and the erection of farm buildings, the charge is in these two points very much lightened to the proprietor of the land. And the benefit remains with him, for the tenant cannot carry away or undo the labour he has expended in assisting the drainage of land, or in the erection of farm buildings. The policy has been questioned of securing by the act the outlay of money on settled estates separate from the inheritance in investments for younger children, as being a fresh edition of ostensible ownership, the next heir being a mere rent-payer for his predecessor's improvements, the rent-charge of which will belong beneficially to others.

unless due judgment is exercised.

for younger children.

The position of the landlord who is tenant for life, and of the farmer who is tenant at will, is strictly analogous. In both cases the outlay of private capital is discouraged, in both cases the natural policy of reducing the extent of land to the means that are at command, is preferable to the expediency of the artificial and temporary aid of loans. The improvement effected by drainage has been allowed an exception to two rules of policy—one public and the other private; the first against the loaning of government funds to individuals, and the other against entering upon investments with borrowed capital. This compliment has been seen

Holders of land for life and at will.

to be well deserved by the operations of the Drainage Act. It has been objected that it goes to keep lands beyond the reach of commerce, which every policy of law should discourage. But in transfers of land very much uncertainty prevails—the new comer may have different views from the old possessor, who may be supposed to have better local knowledge and more solid views of the wants and capabilities of the land. In many cases, loans may be much more beneficial when judiciously applied than an influx of capital, which must seek its way for use, and its vents for application.

both hurtful.

Government loans of money.

The government loans of money can be applied only to the purposes of improving the land, which enables the proprietor to provide for his younger family with the rental of the property. Nor can any heir of land with any reason object to a charge being paid annually for improvements of which he derives both the immediate and lasting benefits. Drained lands are of large value over wet grounds, commodious and substantial farm buildings offer a strong enticement to a spirited tenant, and rising plantations are an encouragement in sheltering cultivated lands for the use of stock. Such provisions justify the incurring of a rent-charge, which differs wholly from common debts that have been contracted for other purposes, and exhaust instead of renewing the sources of the property. No charge claims the name of debt, which pays itself by its own action, as in the case of landed improvements. The peculiar position of many landowners is very much promoted by the government advances of money, the negotiation of which is simple and firmly regulated, and admits no jarring or tendency to litigation. Much good has been done, and very comprehensive benefits will accrue from the inevitable enlargement of its provisions, as has been already suggested in the application to farm buildings, plantations, embankments, roads, water-courses, and permanent purposes of every kind.

Draining, buildings, and planting

most useful.

Encumbered estates,

When an estate of land has got encumbered with debts and burdens that are absolutely beyond the power of recovery, and the property is incapable of supporting itself, or of affording a maintenance to the owners, a power ought to be lodged in the law court of the last resort, by which to sell the property, extinguish the burdens, apply the residue, and convert the land to the free course of the legitimate purposes. The want of this remedy has been long felt, and is now applied in Ireland, where the just expectations are being realized. Such a course is essentially necessary for public purposes, and to relieve the proprietors from a burden intolerable to themselves, and most obnoxious to the future inheritance.

how freed.

The landowner has been gradually relieved of the encumbrances which were placed on landed property in order to secure the successive inheritance at a time when the appropriation of it had not discovered the just purposes of its use, and the true development had not appeared. As population increased, the social organization was enlarged, new wants arose, and fresh demands clamoured for satisfaction. The

Altered policy.

trammels of feudal policy, and the fetters of selfish monopoly, were compelled to succomb before the rise and growth of free ideas and liberal institutions; and the changes that were compelled to be adopted contributed most powerfully to the benefit and aggrandizement of the owners of the soil. The relaxations have been slow and very gradual, and have been forced by circumstances, rather than adopted from conviction, of justice and utility.

Origin of farms.

Experience soon showed that the owner of a large tract of land, even when he has the requisite capital or knowledge, could not successfully become the great farming merchant of his own acres, or employ them so advantageously in any way as by letting them in sub-divided portions to others. This very obvious conclusion soon led to the giving to other persons the use of the lands in definite portions on paying to the superior a fixed quota yearly: first, of personal services; next, of the different kinds of produce; and lastly, of money only. The land was long held by the payment of services and of produce, and the feudal dominion existed over the goods of the tenant in liability for the debts of the possessor of the soil. The holding existed only for the life of the grantor, and for one year during his pleasure. This uncertainty was not removed till near the end of the fifteenth century, when the goods of the tenant were declared not liable for the debts of the landlord, and a tenure for a specified number of years was held good against the successors in the property. These two acts fixed the basis of the position of the tenant, and consequently, of the success of British agriculture.

and of leases.

Policy and security.

The tenant of land is the holder of a certain extent of ground, for the use of which, in cultivation, he pays to the owner of it a fixed amount of money, which is commonly called the yearly rent of the farm, or of the land that is used. On this quantity of land the farmer employs a capital that is at first floating, and gradually becomes fixed, by means of being invested in the soil, by increasing its productiveness, from operations more or less permanent in their nature. Every operation requires the means of performance, and results can only come from causes that are adequate to produce them. The tenant of land who employs these means, most naturally expects to enjoy the results, and to reap the benefit of his operations. He looks to the landlord to grant him the security of enjoying the reward of his labours, and of reaping the harvest of the seeds which he has sown. The position of the tenant is based on this primary foundation, which the landlord cannot with any justice refuse to grant, for he will not himself build a house, make a road, or plant a tree, till the rights of property are securely granted him, and he cannot with any reason expect others to do what he will not do himself under exactly similar circumstances. Capital recoils with instinctive abhorrence from the want of security; and next to the preservation of human life, the safety of property constitutes the leading feature of civilized society. Without this safeguard, capital remains in a useless condition, labour is unemployed, and the population is deprived of the legitimate enjoyments of their vested inheri-

Great value of them.

tance. It is found to be most essentially necessary in every case of rearing a durable superstructure, to find a firm foundation on which to lay the rests of the construction; if it be unstable and shifting, the aversion will quickly appear of refusing to expend capital and time in an undertaking of that precarious and fluctuating constitution. The security must be extended over a time that is sufficient for the development of the intended purpose, which must be calculated in strict relation with the elements on which the action will be exerted. The nature of the productions of land requires a much longer time than many other employments in which to repay the cost of cultivation, years are required for each kind of produce to contribute a share of the outlay that has been made. Hence, a short tenure is nothing better than a yearly holding, if there is more time to expend, there is a very insufficient opportunity to reap the fruits that are grown. "Give a man the secure possession of a bleak rock," says Arthur Young, "and he will turn it into a garden—give him a nine years' lease of a garden, and he will convert it into a desert." It is not possible to banish from the mind of the tenant-at-will the very palpable truth, that every improvement he makes on the land is producing a value to others, and in all probability raising the rent against himself. Besides, the annual expenditure that is necessary to carry forward the current operations, many contingencies occur that are unavoidable, and which trench upon the capital of the tenant. It is impossible to cultivate land in any profitable way without incurring an expenditure more or less beyond the bare necessities of a pinched utility of the ground. The tenant may have a well-grounded and unbounded confidence in the owner of the property, that he will not be disturbed by him, nor denied the fruits of his labours, but he has no knowledge of the successor—a widow in straitened circumstances, who may be compelled to use every means to raise money—a minor under unscrupulous guardians, who will stickle at no point in order to accumulate the wealth of their charge, or some prodigal hunter or lover of the turf, who, in order to gratify his passions, cares not for to-morrow, nor even for the afternoon of the present day. These, and many other changes of a similar kind, stare in the face the tenant who depends on the faith that is not beyond chance and accident, and convince him of the inconvenience of his situation, and the irksome apathy to which he is reduced. The consequences never fail to re-act upon the landowner himself, who finds a diminution of his rental to happen yearly, in order to supply the necessary demands, of which the situation of the tenant prevents the performance. He soon finds that it is much easier to uphold than to restore, and that fertility when once abandoned, requires much time and cost to be repaired. The tenant finds a constant diminution of his supplies, and fears to use the means of increase, as others may obtain the augmentation. Habit and custom may accommodate the minds of men to such a mode of tenure, as by it the natural indolence is cherished, and exertion is not required. A rent is raised by certain means which have been long practised, and are well understood; no prejudices require to be removed

Length of tenure,

most essentially necessary.

Danger from want of it,

and its evils

nor any entertainment made of troublesome innovations. Exertion and independence, which are the life and soul of industry and exertion, are wholly lost. Not only all great improvements, but even the most common works of the season will be imperfectly performed, and little can be hazarded beyond the expenses which the returns of the year will defray, when the farmer cannot look to the future with security. Capital will be sparingly expended on another man's property when that security of possession is denied, which is essential to the safe and profitable application of money; the agriculture of the country will never arrive at the advanced condition of which it is susceptible; and the persons employed in the occupation will lag behind the other productive classes in their means of improving their art and acquiring knowledge.

upon every kind of proceedings.

Not only the landlord but the country suffers by the less improved condition of the public territory, from the want of just and fitting tenures on his estate. Much land remains uncultivated, or is kept in a very inferior condition of growing grass, which renders security of comparatively less value, as the land requires little expenditure, that cannot be replaced within the year, and a long possession is not absolutely necessary to enable the rearing and feeding of cattle and sheep. This state of things incurs a large diminution of the general production, in which every individual of the community is interested, from the peasant at the plough to the peer who legislates for universal satisfaction.

Cultivation is lessened.

It has been urged against leases of land, that the farmers themselves set no value upon them; but this argument leads to a very different conclusion than the intended contradiction. The absence of security has engendered an utter ignorance in the cultivation of the soil, of the means of employing their own capital with advantage, has indisposed them to the exertion which improvements demand, and has produced a better contentment, with an easy rent and dependent condition, than with the prospect of an independence to be earned by an increased labour both of body and mind. The rent is lower and requires less exertion, and the eye having been accustomed to behold one state of things, no other condition can be entertained. This tenancy having become the habit of the country, not only re-acts upon the condition of the occupiers of farms, and the means of perfecting their own art, but it affects, essentially and directly, the interests of the landowner and the country.

Ignorance and indolence are produced.

The only fitting security for a man who has capital to employ in the cultivation and improvement of land, is a written covenant subsisting for a definite and adequate period. The term must be defined, in order that the property may not seem to be alienated, and the period of time must be adequate, to draw back by periodical returns, in the lapse of years, the capital that has been expended. It is the peculiar nature of the returns from land to be extended over a number of years, and to be obtained in a succession of crops that are allowed by the season; and not only is a period required to effect the operation, but a time likewise to recover the funds expended. The employment completely

Written covenant the best security.

differs from manufactures of perishable articles; the results of one operation are generally sufficient to reimburse the outlay, and the capital is restored with recompense. The changes of summer and winter do not interfere with the proceedings, nor does the want of security affect the use of the means that are necessary to promote the advancement. The machine is the property of the person who erects it for the purposes of trade, and the more perfect it is made, the more profit will be derived by the owner. But no such assurance rests with the cultivator of the soil, who tills the great machine on which his all depends. It is the property of another, who will in the end profit by the improvements which are made by the temporary possessor. The manufacturer receives directly the profits of his stock in trade; the farmer must share the profits with another, who risks neither money nor labour. The farmer is fettered by conditions imposed upon no other class of traders, and the inconvenience of obtaining returns for the current expenditure more slowly than in any other occupation, are frequently attended with the uncertainty, if the capital advanced can ever be recovered. The employment of capital on the property of another, must ever be attended with certain drawbacks that are not easy of adjustment with relation to the value of the returns: but the insecurity with respect to the future, and where the possessor cannot employ his funds in the manner which his interest requires, will greatly increase the inconvenience and perplex the equitable adjustment in an affair where just concessions are essential to any legitimate compromise.

Land differs from Manufactures.

Longer security necessary.

The security of possession being the basis of the position of the farmer, constitutes the foundation on which all the other relations depend: without it, the very best arrangements, and the most favourable subordinations are impotent and wholly useless. Not that other points of position do not bear a part in forming the proper place in which the cultivator of the soil must be located. The sequel of this chapter will show the value and necessity of the accompaniments; but unless they are based on freedom of action and security of possession, no corresponding benefits accrue from the attendance of the isolated attachments. The action of the whole possessions is paralysed and rendered of none avail, by reason of the want of the lever power to raise the joint operations. With every propriety and the utmost justice, the security of tenure in land for an adequate period of time, is made to occupy the first place in every arrangement of relations between the owner and occupier of the soil. No sane person will involve himself in any undertaking without that essential provision.

Security the base of farming,

with every propriety and justice.

The capital of the farmer being expended on security of tenure, comes next to be used upon the capital of the landlord, which is sunk in the permanent provisions which are required to make the land advantageous to the occupier. These provisions constitute the furniture of the farm, without which the occupation cannot be converted into the beneficial purposes. The nature of the utensils is durable, as being fixed upon and growing in the soil, and continue for years

Furniture of the farm provided by landlord,

to fulfil the intentions of the formation, consequently they become exclusively the province of the landlord, and are entirely of his concern in the cultivation of the soil. The outlay of the necessary fixed capital must be regarded as that which falls peculiarly and primarily upon the owner of the land, and which cannot be devolved on the temporary occupier without a more than corresponding sacrifice of the permanent interests of an estate. The capital being expended by the landlord, who receives interest on the outlay, in the form of the greater rent which the land is rendered capable of yielding.

The two interests involved in the profitable occupation of the soil, are the permanent and the temporary, or the owner who holds in perpetuity, and the farmer who uses the soil for a specified duration. Hence the provisions that are durable in nature, and which fulfil the purposes of use for a length of time, are very naturally assigned to the cost of the landowner, whose interest in the land accords with the services of the provisions. To the tenant who holds for a fixed period of time, there is naturally assigned the temporary upholding of the furniture which he uses, on his receiving the raw material of which the furniture is made. This arrangement well coincides with the temporary interest of the tenant. He uses, but does not afford; he repairs the wear of application, but not the decays of nature; and maintains the fixed appendages in the current going order.

upheld by the tenant.

The first object of attention and necessity in the cultivation of land, is the adequacy of the houses, or buildings, for the use of the farmer: and of these erections, the chief attention is the dwelling-house to be inhabited by the family of the farmer. The comforts and elegancies of life have descended in Britain to the degrees of capital which have been established among the different grades of society, each class challenging and expecting that their vocation shall afford equal accommodation with similar grades of employment. The reasonableness of this expectation cannot be disputed; the manufacturing classes have shown the way, and the agricultural employment must necessarily follow. Scarcely any provision will form a stronger inducement for the occupation of land than a dwelling of suitable accommodations, at least to the respectability, which it must ever be a leading object with the land-owner to induce, to settle upon his property. Several wants and inconveniences will be overlooked, and even very necessary demands will be relinquished in cases where this primary provision is fully complete, and when attended with a well-stocked garden and orchard, the owner of land cannot devise any more alluring objects to the eye of inspection. Vegetables and fruits are now indispensable articles of almost daily consumption, and a rural dwelling loses the name without them.

Dwelling-house on the Farm.

Garden and orchard.

The farmer having seen on a farm a suitable accommodation for his family and domestics, next proceeds to examine the buildings that are intended for the protection of animals, and the manufacture of produce. These erections must exist in the corresponding degree of convenience

and usefulness, and in the number requisite to the amount of business to be performed. The inspecting tenant, if he be of the enlightened sort, will speedily ascertain if the number and arrangement of the buildings will suit the purposes of cultivation which he intends to adopt, and will point, at the same time, to the wants that appear, and suggest the amendment. That the greater part of the farm buildings of the present day

General buildings

are sadly deficient, no person offers to deny; but it is pretended that no substitution has yet appeared to warrant the removal, or that no complete form has yet been devised beyond which no advance can be made. But from deficiency to a completeness of no further progression, many steps intervene, and very much usefulness is contained; neither nature or art advances by such extended leaps, but by gradual steps of progressive ascent. Improved designs of farm buildings are known which will command five per cent. on the outlay for the lease of twenty years, separately considered as an item, or will add very considerably to the general rent of the farm. Without the proper accommodations, the live stock cannot be bred and reared, with the known advantages,

are most necessary.

nor can the grain produce be manufactured with the economy that is requisite in the detailed business of farming. It is idle to pretend that ideas are undetermined on the subject of farm buildings, the progression in that point is equal to the general advancement, and the adoption is only prevented by the general aversion to change. To wait for a "*ne plus ultra*" perfection on any point, would delay all human progress.

The cottage dwellings of the labourers that are required on a farm, claim a most especial attention both from the landlord and the farmer. Till of late years, this department found no notice in the general estimate of the furniture of landed property; the old hovels, resembling pin-

Labourers' cottages

folds, were considered sufficiently good, and the horses and dogs had more consideration than the labourer, who is the life and soul of every act and operation. Some considerate landlords have led the way in erecting very much improved dwellings for the accommodation of labour; and philanthropy has appealed to the feelings of human nature in behalf of the hitherto neglected portion of the community. The farmer must see that he has got accommodation for the labour he may require, afforded in the necessary quantity, and placed in the proper convenience. Any want on that head, will form a very great determent to the embarking of a floating capital to be productive of mutual benefits. Immorality

are indispensable.

and disease have been widely propagated from the confinements in which cleanliness cannot be adopted, nor the decencies of life maintained. The civilization of the present age demands a wider step being made at once on this point than on almost any other provision of the social system. When a moderate exaction in the shape of rent has been arranged with the farmer, and the land has been amply provided with the fixed capital that is necessary for the development of the floating funds of the tenant, the attention of the landlord should descend to the condition of the labourer, by the employment of whom both his own

station and that of the cultivator of the soil is raised and upheld. Capital is merely an accumulation of labour, and it is just and reasonable, morally binding, and religiously imperative, that its attention be directed to, and its care be bestowed upon, the comfort and maintenance of the source whence it originates, and by which it is sustained. The owner of the soil has wholly in his own hands the power and the means of providing comfort for labour in suitable cottages, garden grounds, bakeries, pig-styes, and the supply of water: but he is unable to fix the wages of labour, as it is a marketable article, and liable to the fluctuations of supply and demand. But it is more stationary, and much less evanescent than those articles that are strictly perishable in their nature, and it is capable, if not of a permanent adjustment, at least of a temporary understanding, as to the amount of the remuneration. With this view of the matter, the farmer may be understood by the landlord to pay labour in the highest rate that is known to be given in the district, and if that amount be low, an advance may be led in a small progression. The state of society does not yet admit a binding clause to this effect in an agreement of demise and use, but it is quite possible to introduce a tacit understanding of the performance, which may soon lead to a public avowal of the arrangement, than which nothing will more powerfully conduce to the strength of society. It will rivet fast in affection the contiguous planes of the social organization, and solder the jarring elements of discord, it will multiply the strength of every chain, and link together in a firm union all the junctions of the mixed connections. Of all the plans that have been designed, or that may be intended for the amelioration of the labouring classes, none is so simple and so effectual as the increase of the commodity by which are obtained the essential necessaries of life; and in the case of farm labourers, the landlord must lead the way in the provision of the fixed articles in dwellings and their appurtenances. An example must be shown from the highest quarter, and then the next lowest can be used by treaty to confirm and uphold the arrangement. Though the figure of the numerical amount of wages be not named, the sum can, nevertheless, be entertained in a tangible estimate.

Accommodation and wages.

Roads, affording a convenient and ready access from the farmery to the different parts of the farm, are a very essential part of the provisions that are required by an extent of cultivated land. Most farms adjoin a public road, or are intersected by it, and the private roads will be much guided by the public line, both in the direction they are made to take, and in the number of the paths they afford. The roads must be durably made by the cost of the landlord, and the keeping in repair devolves on the tenant. The farmer must see that the quantity of land which he intends to rent is suitably provided with the necessary intersections of access, or the animal labour will be much harassed, and the wheel carriages be unnecessarily worn.

Roads and gates must be amply provided.

If any rivers or large brooks of water run through the farm, or form the boundary of it on any side, the overflowings of the swollen state must be prevented by suitable embankments, and the courses assisted by being

straightened and thrown at the turnings into the proper channel. The farmer must observe that no damage will happen from overflowings of sluggish streams, nor from alluvial flats being torn and wasted by impetuous torrents, rushing against the banks and wasting the soft materials. If neglect has allowed these devastations, the loss must be estimated, and the recurrence prevented.

Fences and gates constitute a part of the fixed capital or furniture of a farm, that demands a very ample fulfilment on the part of the owner of the soil. Fences enable the farmer to guard his crops from damage, to separate the different kinds of beasts, to divide into suitable lots the grazing animals, and to use the fields of land in the due rotations of cropping. Without divisions, these purposes could not be attained, nor the value of the land realized. Gates are no less necessary to open and shut on the gaps in the fences that are left for a road into the fields, and which afford an ingress and egress to the animals, and to the wheeled carriages and other implements when the fields are cultivated. The fences must be complete for the purpose of confining the lots of animals, and the gates must be ready in the action, and strong in the form.

Fences a special care.

The provision of water for some special fields of the farm may be mentioned as an appendage to the necessary furniture of the possession. A field or fields may be required for cows' pasture, one for horses or young cattle, to which water may be brought by boring, or in pipes from a distance. This provision is not general, but may be very properly hinted in this place.

Provision of water.

Equitable rents must occupy a large consideration in fixing the position of the cultivator of the soil. Rent is the surplus of the value of the produce of the land that remains after every labour is paid, and the farmer's family maintained. This original and very just definition of rent has been much encroached upon, and almost wholly overturned by the revolutions of society, which have brought the word to mean the market price of the soil as an article of commerce for the specified time, from which the other considerations are wholly excluded. Two elements in the present day, which cannot be separated in practice, constitute the payment made by the farmer to the owner of the soil, the simple price paid for the use of the land, and the interest on the fixed capital in the buildings, enclosures, and other improvements which have added permanently to the productiveness of the soil. It is not necessary for our present practical purpose to make any illustration of the theory of these separate elements, or to pursue the paths of investigation that have been followed by political writers, in order to explain the nature and causes of rent. All land in this country capable of cultivation, yields a rent; and also if it produces the grasses in sufficient quantity that feed the domesticated animals, the rent will bear a proportion to the fertile or barren quality of the soil, the favourable position of the farm, and the advantages of occupying it by buildings and other necessary adjuncts.

Rents must be equitable, and practically adjusted.

No rules can be established in respect of the proportion of the value of

the produce that shall be paid in any case as rent. The mode of agriculture that is pursued, and the habits and condition of the tenantry possess a large degree of influence, the nature of the returns, whether it be corn or animal produce, the labour that may be required, both in quantity and quality, and the natural constitution of the land; these are chief objects of consideration in making an estimate of the probable amount of rent. A larger produce is raised by the same labour when used under an improved system of tillage, and higher rents can always be paid where agriculture is most improved. The general variation of rent is from one-fourth to one-half of the value of the gross produce, the portion of one-third yet prevails chiefly in the case of permanent grass land. The rent depends on elements that vary with the nature of the soil, the kinds of produce, and the skill of the farmer.

Highest under improved tillage.

The actual profit to be derived by the farmer must bear a ratio to the capital employed by him. The best regulated calculations award him fifteen and even twenty per cent. with which to support himself, and bear the risks of his trade. The fixed capital which must be advanced, should form the first calculation with the farmer who rents land for use. The landlord's rent and the expenses are left after allowing fifteen per cent. for interest, the profits of stock, maintenance, and the risks of trade to the farmer.

Per centage allowed the farmer.

Rents might be fairly adjusted if the prices of produce remained the same or nearly the same; but the greater or less supply causes fluctuations, and also causes that could not be foreseen or provided against at the time of contract. Fair assumptions with respect to prices and produce form the safest ground for those who let as well as for those who take land, and founded on their knowledge of the past, joined with reasonable analogies with respect of the future: these data will lead to safe conclusions about rent. Fewer mistakes would be committed both by landlords and tenants, if more care was bestowed on the above assumptions. There is a constant tendency in Britain for rents to rise rather than fall, from the difficulty and necessity of finding employment for capital, and the limited supply of farms in the market. There is ever a greater hazard that the landlord shall receive or obtain the promise of too high a rent from the eagerness of competition, than that he will suffer loss from the land being underlet.

Rents tend to rise rather than fall.

This tendency in the rent of land to rise, and the causes which produce it, claim an important attention in the management of landed property; it should be partially checked, rather than keenly encouraged. A landowner or any other proprietor never can be able to take an impartial view of the value of that in which he has so great an interest in rendering available as a source of income; but in every view of the subject, the farmer, must be allowed, such a profit as will enable him to cultivate the land, meet the contingencies of trade, and maintain his family comfortably and respectably. A deficiency of profit hazards the trenching upon the capital of the farmer, which diminishes and dries up the source whence is derived the rent and revenue of

Must be moderate to allow competency.

the landlord. The loss of the requisite funds is the greatest of all evils that can afflict the farmer, and the recovery from it is the most difficult. A retrogression once begun on this point is gradually quickened in speed, till it ends in total ruin.

Sound policy directs, fair dealing justifies, and good practice supports the rule, that a fair and lenient exaction shall be made on the industry of the farmer. The most certain and steadiest revenue is ever derived where fair and moderate rents are exacted, and not from the sources of improvident demands and severe treatment. No landlord ever profits by a system of exorbitant rents that is rigidly enforced. A few years suffice to exhaust the capital stock of the tenants: the stoppage of improvements, the failure of tenants to fulfil their obligations, and the general deterioration of the property, both in condition and character, are the certain results of the continuance of rack rents.

Exactions must be lenient.

Acts of great liberality are published in returns of rent being made to the farmers at the audit days, of ten, fifteen, and twenty per cent. In special cases of a sudden contingency, such acts are necessary and proper, but as a general system, the management must be bad that calls for the constant repetition. The fair adjustment of rents needs no temporary bounties, it must be able to bear the pressure of low prices and of deficient crops; and it must allow every tenant the means of meeting the contingencies of trade that arise from the fluctuations in the amount and price of his commodities. The rent should be at once reduced, when land is seen to be overlet, and the tenant's condition constituted to meet the demands and engagements. A rack rent, and the relief or charity of an audit day, create a dependence not to be endured. The quarter of a century of years that followed the termination of the late European struggle, has left a lesson to succeeding generations, and one which may never be equalled, and far less exceeded. Prices of all articles fell in an unprecedented degree, the landlords clung to the rents as engaged for, the tenants could not pay them, temporary expedients were adopted, capital was swept away, and more efficient remedies were compelled to be adopted. The necessities of the case being promptly met, and new arrangements being made with the tenants and suited to the altered circumstances, no damage ensued to landlord or tenant, the interests were preserved from the ruin that attended the denial of justice. A prosperous tenantry, and the improvement of an estate, will not proceed from the feudal fashion bounty of an audit day, but from the condition of the tenants, enabling them under a fair and well-considered covenant to fulfil all obligations, and meet and surmount every demand that is made upon them.

Adjustment of rents,

to suit altered circumstances.

Much local knowledge and correct enquiry are necessary to enable the forming of an estimate of rent of land. Each district has its peculiar advantages and drawbacks, which are known to, and can only be estimated by, enlightened practical men who have resided in the country, and have learned the calculations. A professional stranger with a long array of figures and calculations, only leads the land-

Local knowledge necessary

lord into mistakes, anent the real value of the estate, and the means of entering into equitable contracts with his tenants: he must draw information from persons who are better informed than himself, regarding the letting of land in the district, and the current value of the soil. But local surveyors are always found of some experience and observation; and if they have a character of integrity, they can furnish the best local knowlege of the value of land. These persons being joined with the country agents of the land-owners, and if both parties are left undisturbed by the proprietor himself, who is generally the least qualified of any one to form an impartial judgment, will produce the most correct and best arranged estimate of the value of the cultivable soil. The improvements that may be effected, will probably come from a more comprehensive view and more adventurous judgment and spirit of action. Even in that case, an especial attention is ever due to the observations of local knowledge, and to the practices that have been established by the experience of ages. The most enlightened judgment will never despise to hear any truths that relate to its occupation.

even to conduct improvements.

Beneficial terms for the management of a farm, constitute a most important condition in the relations between landlord and tenant. The temporary occupier of land is necessarily entrusted with the management of the farm during the period of his possession; and if he consults his own interests truly, he will conduct the cultivation of the soil in the manner best calculated to maintain or increase its productiveness. But knowledge may be wanting to adopt the proper means, and his interest, real or apparent, and even his necessities, may lead and compel him to attempt to take more from the farm than is compatible with the preservation or increase of its productiveness, and especially towards the end of the lease, when his interests and those of the landlord begin to diverge. The written contract is devised to guard against these results, and to allow the one party the privileges that are necessary to carry on his business, and to the other, a legal security that these rights shall be employed only in the purposes contemplated by the parties to the contract.

Terms of management,

The essential conditions must be few in number, easily understood, and as easily complied with. No questions need occur in a well-considered contract, which must not be made up of a multiplication of conditions, penalties, and restrictions, which only serve to perplex, and afford the fruitful source of litigation. The expressions must be so pointedly obvious in the meaning, that no doubt can arise in the construction. Two faults are usually committed, a mass of cumbersome and useless restrictions fetter the judgment of the farmer, and cramp his energies, prevent the exercise of judgment, and the powers of adapting the practice to the circumstances that may arise: the other omission consists in leaving to the farmer an unrestricted power of proceeding to a degree of management very hurtful to the landlord, and on every change of tenants, tending to a deterioration of the farm. The midland and western counties of England are oppressed with clauses and enactments that have descended from the practice of olden times, and

simple and pointed.

Two faults common.

which either remain a dead letter, or kill the freedom of action that is demanded by an improving condition of the tenant. In Scotland, where the lease of land has wrought miracles of the kind, a remarkable degree of laxity prevails, and whole estates are managed on a simple letter or a memorandum with constant reference to the custom of the country. The details so essential to the interest of both parties, are wholly neglected; towards the end of the lease, land is scourged, buildings are dilapidated; and in cases where a removal is inevitable on the part of the tenant, stipulations and restrictions are essentially necessary, though they must be few: an excess of caution and of laxity, is equally to be avoided, in order that the interests of both parties may be secured, the landlord protected, and the tenant disencumbered of useless verbiage and unmeaning phraseology.

Restrictions.

Not only individual interests are damaged by the neglect of the necessary regulations in the ownership and temporary possession of land, but the general interests of agriculture do suffer in a very high degree. The progress of the tenant is retarded by an adherence to obsolete customs and antiquated practices; the very worst rules are often enforced, and often all directions are wholly merged in the weighty consideration of the amount of rent, and the times of payment, not forgetting a penalty in case of neglect. If good farming cannot be introduced by the stipulations of a lease, it may, at least, prevent much that is bad, and by wholly omitting the notice of exploded practices, room is left to mention the better rules, and to render them compulsory when time has fully sanctioned the superiority. The practice of agriculture clings so very tenaciously to old customs, that every possible means must be used to unfetter the bonds and loosen the grasp, and many very useful notices may be made in the small compass of a lease. A mass of stipulations and restrictions, and the total want of conditions, are equally objectionable: a number may be refused, but some are necessary.

Bad farming may be omitted.

The essential conditions of using land in cultivation, may be recapitulated: 1. Security of possession for a proper length of time. 2. An adequate provision of fixed capital on which to employ the floating funds of the farmer, in farm buildings, enclosures, and other necessary appendages of the land. 3. Equitable rents. 4. Suitable conditions in respect of the treatment of the land and general management.

The conditions that are essential.

All experience has shown that the means of advancing and perfecting the agriculture of Britain as a branch of public industry, depend essentially upon the relationship which is established between the land-owner and the farmer. No attainments on the part of the tenant, no varied and comprehensive professional learning, and no eager willingness to exert these advantages, are able to compensate for the want of the foundation on which the edifice must rest: the structure must be firmly based, or no elevation can be raised. Even the possession of a large capital by the farmer, will not avail for giving to agriculture the means of successful cultivation and improvement, the owner

and that cannot be compensated.

must be given the means of employing it with advantage, by security of possession, by the privileges required for the proper management of the business, and by that fair and lenient exactions upon his industry, which will enable him to employ his capital with a remuneration.

If these conditions are withheld, the capital employed in the cultivation of land is exposed to drawbacks in the application of it to the proper ends, which diminish the possible returns and also the means of improving the national source of wealth to the degree which is admitted by the case of adaptation. The improvement of the country, and of its agriculture, follow as a sure consequence, whenever along with the power of acquiring capital, the means are afforded of applying it with effect to the legitimate purposes. And wherever these conditions are supplied, agriculture improves, education and intelligence are extended amongst the large body of the farmers, and each succeeding generation excels the preceding one in the knowledge acquired, and the means of employing it for private advantage, and the general welfare. To these benefits must be added the tendency to advance the wages of labour, and the improvement of the dwellings of the lower grade of society, which sustains the upper in every stage of elevation.

Benefits of their being granted.

"To do as he likes with his own" is a definition of human privileges that sounds most agreeable to the love of power which so very strongly actuates on the will of man. But the sound will be found to contain the whole boast and extravagance of the often quoted phrase. A thousand obligations and influences surround the will and conduct even of the most apparently irresponsible and unfettered owner, controlling him by an operation far better and less easily evaded than legal compulsion, to consult his own interest by considering that of others. In the capacity of landlord, nothing is wanted but a knowledge of his own true interest to render this principle effective to a degree unsurpassed, if indeed equalled, in any other relation which one man can bear to another. One axiom comprehends nearly the whole that has been, or which may be said on the relations between landlord and tenant, that of all of the encouragements to the tenant occupier that exist, of all the stimulants to individual improvements that can be devised, the surest, the most legitimate, and in truth, the easiest and most permanent in effect, is to make every tenant feel to the utmost possible degree that the farm to which he devotes his labour and capital is his "own." If it be true that the best tenant is he who treats a farm of land as if it was his own, it can scarcely require proof that the best landlord is he whose tenant is least made sensible that he is not his own landlord. Paradox as this has appeared, and may still seem to be, it is the only statement that approaches the whole truth of the case. The relation is one of that class which, like the functions of animal life, are most healthily discharged when they are not felt.

The utmost supposed freedom underlies obligations.

The grand axiom of tenancy.

The rents and profits of the land are the owner's, and his only: with regard to the soil, in every thing he does with it, and in every thing he

abstains from doing, he is bound to make his interest and pleasure consistent with public good. The community still retains of its original claim to the soil of the planet it inhabits, as much as is compatible with the purposes for which it has parted with the remainder. The land-owner inherits or has purchased the superior interests of the soil and by that possession he takes upon himself the duties which God and nature have placed upon it. The development of the resources of the land rests upon the arrangements that are made for the use of capital in its cultivation, and labour expects employment and maintenance from the vested interest of its inheritance. The moral condition of the people is vastly promoted by the ownership of the soil, which affords to the public use the means and materials of promoting its respective undertakings. A liberal policy on this point has promoted the cause of humanity beyond many other seemingly more urgent causes of impulse. The most selfish and shrewdest utilitarian that ever sought out the shortest road to his own interest, may take an advice in the shape of a moral recipe to the owner of land, to realize the feelings of the tenant, to put himself imaginarily in "his" position, so as to be able to enter into his wants from "his own" points of view, and never to discard the just idea, that the well-being of every creature is not only compatible with, but essentially necessary to, his own. The owner of land is morally bound and socially obliged, by the performance of many duties, and the bearing of many charges, which do not fall on other classes, and are not attached to property of other sorts and constitutions. Though no class of the people are now held to be "*adscriptæ glebæ*" or to form part and parcel of any landed property, yet on the soil, their education and maintenance is devolved, and becomes the duty of every land-owner to have performed. By granting to the farmer the essential conditions that have been mentioned, and by refusing no reasonable demand, by which is acquired a fixed interest in the soil by the cultivation of it, the land-owner has the power of introducing into agriculture as great improvements in point of production, as the invention of the spinning-jenny or the steam engine. To these must be added the adoption of every new principle that tends in practice to economise labour, and cheapen the price of articles by which to extend the sphere of their use. While a population exists, the earth must be cultivated; and the very first responsibility rests with the virtual owner who has both the means and the power that are required for that purpose. No individual in private life possesses the same wide scope of moral capability with the resident land-owner, in the most variously inviting field of practical studies and duties. The leizure it affords is a high priviledge, and leads to the pursuit of important and humanizing objects, which lie open in the same degree to no other condition in life. The pursuit of gain is sufficiently attractive without any over-exactions, and which is allied with and not arrayed against the enjoyment of natural pleasures, while the love of distinction so natural to most minds, is indulged by a prominence almost inseparable from the

The rents "only are the owners;"

the other rights in the soil.

The scope of land ownership.

position it confers. Example, almost the effect of law, invests it with a commission both wider and higher than the magisterial authority which generally forms one of its leading duties, while the daily recurring sphere of rural economy in many problems that required solution, and the wide field of practical and scientific knowledge involved in them, demand a breadth of varied education, in the fullest sense of the word that is not exceeded by the learning of any other branch of professional life. Till the general education happens of the whole body of the people, the extensive influence of the owner of the soil, and the commonly great early advantages, form a source of very powerful central force, from which will emanate a wide dissemination of the most useful knowledge, and of the accompanying moral and physical blessings to the human race.

legal and social.

The last to be mentioned—relation of the landlord and tenant—consists in the case of the non-fulfilment of the terms of the contract. The landlord pursues for the rent by entering a distress on the goods of the farmer, or waiving his right of distraint he can proceed by action at law. The tenant can proceed by action against the landlord in default of the performance of his part of the contract. But the equitable adjustments that should prevail will wholly prevent these disagreeable resorts.

Landlord's means of recovery.

The much agitated uncertainty about fixtures on the soil has been settled by a late act, which directs the farmer to give a month's notice to the landlord of his intention to remove a fixture that has been erected by himself with the consent of the landlord, within which time a negotiation of purchase by the owner of the soil can be effected. But in all such cases a special agreement settles every point, and on the simple principle that "*conventio vincit legem*," all disputes are completely removed. In making agreements of any kind, the chief point of attention is the simple plainness of expression, by which all ambiguity is extinguished, and every doubt dispelled.

Fixtures.

Validity of simple agreements.

CHAPTER II.

LEASE OF LAND, CONDITIONS, AND RESTRICTIONS; CHOICE OF TENANT & ASSIGNATION OF THE DEED.

A LEASE of land, is the demise, transfer, or letting of the ground by the owner of the soil, by which he grants for a specified time, the use of its productiveness to another person, on condition of receiving a fixed amount of money as the consideration due to him for the value of the temporary occupation. It is a written agreement between two parties, who engage to perform certain stipulations and restrictions by mutual consent, and it contains the specified conditions on which the

Lease defined.

agreement is founded, and the times at which they must be fulfilled. The conditions are obligatory, and even compulsory, and contain the grounds of proceedings to enforce the observance. It possesses the power of making itself respected, and of commanding the obedience of the parties that constitute the formation of the agreement.

Form to be neat and concise.

From having contained much useless phraseology and unmeaning and irrelevant verbiage, the lease of land has been reduced into a neat form concisely worded, and pointedly expressed, calculated to lead rather than hinder, and to improve rather than deter. It has been cleared of the feudal tendency to enervate the mind and fetter the energies of man, and has been converted into an instrument by which to serve the purposes of the human race in the different grades of which the mixed society is composed. Necessity compelled very early the assigning of land for the temporary use of employment, but the advantages never became extensively beneficial till the goods of the vassal were freed of responsibility for the debts of the landlord, and a lease from one proprietor for a specified time, was held good against the successors in the property. From that time, the lease of land has become the basis of agricultural improvement, and a very great source of national wealth. To govern and use landed property without the security of tenure, and of capital, and without some general stipulations, is the same thing as if kings and deputies would rule "arbitrarily" without any laws or written customs, which is wholly repugnant to all just ideas of modern civilization, and the privileges of natural right. Landed property is loaded with the burdens which God and nature have imposed upon it in employing, maintaining, andeducating the people, and in every properly constituted social system, there must be no dependence of any class of persons upon another, except in the simple affair of exchanging value for value, or as the Latins expressed it, the "*quid pro quo.*" The love of dominion, and the inclination to be under masters, are equally to be dissipated and abolished.

Twenty years the best length of tenure.

The most eligible duration of a lease of land has now been fixed by the best experience in the term of twenty years. Twenty years is a very unusual term in the home counties—7, 14, or 21 has the preference. This period has been reckoned a long term during which to part with the control of property, and lose the advantages that may happen of an increased value—but it has been proved to be in a fair accordance with the interests of both parties to allow the possessor to adopt and use a profitable system of management, and the landlord to derive an adequate rent.

Prospective view.

All the operations on a farm, except those required for the cultivation of the ground from season to season, have a reference to future years for the returns to be obtained, and periodical returns after the lapse of a certain period are required to regain the capital that has been expended, beyond the funds of the ordinary routine. Unless the farmer can look forward with a certainty of future recompense for the expenditure that may be made, no farm can be cultivated in a suitable manner in this country. The most common executions need a time to be performed, and

the farmer requires a further time to get back his capital with a profit. The space of eight or ten years is required for the development of long known applications to land; and more expensive and lengthened processes, are daily being pushed forward, by the ingenuity of science, and the researches of enlightened practice. In many cases the erection has been done by the tenant of thrashing machines, driven by steam, which cost a very considerable sum of money, and which never could have happened unless an adequate time was secured in order to derive the expected benefits. Owners of land require every security which can be given to permanent property in order to induce them to improve their lands; and they must consider that where a lease is denied, no reasonable expectations can be formed of the tenant deviating from the path adopted by themselves. No proprietor of land should ever think of withholding some equitable share of the privileges he has claimed, and has obtained, or rather has taken to himself. The general benefit of society and the individual good of his fellow-creature, most earnestly and justly demand this privilege through his hands. A more liberal policy is loudly called for in order to second the exertions of genius, and of accessory science, which attempts to promote the advancement of an art on which national prosperity so very much depends; for without it, societies may meet, the chemist may analyse, and the philosopher will lecture in vain. General success in any business depends as much on the social policy as on individual exertion, which must be free and unfettered, and in every way encouraged. The period of twenty years cannot be regarded as an extension beyond the nature of the pursuit, nor in any way unconnected with the interests of both parties. Very rich lands will sometimes occur, which require little or no expenditure beyond the ordinary expenses of tillage; and on these soils, a long tenure seems less necessary than on improving grounds of more or less extent. But these exceptions are not very general, and even there the landlord will derive but little benefit from abridging the lease unduly : he will excite the attention of the tenant in closely cropping the land in order to have a guard on his outlay, and to be ready for a removal with as little as possible lagging behind. Short leases are worse than none—they provoke an inclination to expend, but afford no foundation of action—they afford a time to lay out money, but none in which to recover the amount : so that no advantage is conferred except that the tenant is not liable to be ousted for the number of years mentioned on the rent being duly paid. But in point of inducing improvements by the outlay of capital, a yearly tenancy is just as effectual as short terms of tenure. Time and experience, the most convincing of all teachers, and the most despotic of all governors, have long since most satisfactorily settled the irrefragable truth of the above observations.

Time for outlay by the farmer.

Equitable privileges not to be withheld.

Social policy necessary.

Shorter tenure for rich lands.

The lease of land settles, 1, the time of entry to the farm, the duration, and the issue of the tenure; 2, the amount, and kind of rent, and the terms of payment; 3, the stipulations regarding the erection and keeping in repair the buildings, fences, and other

Settlements made by the lease.

fixed appertainments of the farm; 4, the rules and conditions of management; 5, the reservations made by the landlord; 6, the rights of the respective parties who contract the agreement.

The period of entry to farms of land are various, in March, in May, in September, and in November. The custom of the district generally establishes the time of entering into the possession of land, and not being founded on any uniform principle, much embarassment has accrued in the management of landed property. In March, there remains much produce unconsumed of the crops of the former year; and too much interference is occasioned between the outgoing and incoming tenants, by the former having to use the farmery in manufacturing the remaining goods of his possession. In September and in November, the whole crops of the year have been produced by the expense of the outgoing tenant, and they must be manufactured during the winter, by his own arrangements in the farmery, or sold by auction, or to the incoming tenant by valuation. The Michaelmas entry prevails much in South Britain, and is found to be attended with great inconvenience. The green crops are on the ground, and the whole expense of raising them must be repaid to the outgoing tenant: the tillages of the former year are not exhausted by one crop, and a value is owing: manures otherwise used for one crop, must be appraised in the forthcoming use: copse woods that are cut for fuel and sale, are valued in the standing growth, and thus a large amount of valuations comes against the incoming tenant, and must be paid in ready money before he enters upon the ground: the grain crops are lodged in the barns, or built in ricks, and are converted into money during winter by the outgoing tenant, who may be removed to a distance: the connection is thus continued which should be ended when the possession is quitted, and a large amount of money is required at the entry, for which no return is made for some time. This time of entry, with all its customs and dues, will be found amply detailed in "*Bayldon, on Rents and Tillages*," (Longman,) and in the former part of this work, edited by Mr. Ryde, where valuations are given as examples, and accurate comparisons are made. The alteration of the term of entry to the spring, would require a sacrifice on the part of the landlord of the whole appraisements due to the outgoing tenant, and thus set clear the entry to the new possessor. The sacrifice would be very considerable, and the advantages may in some respects seem distant—but it would prevent the large demand that is made on the incoming tenant, and leave the money thus expended, to be used in making other improvements. The inconveniences of the present system are very frankly acknowledged, and the benefits of a change largely anticipated, but custom has got a very firm hold, and habit exerts its prerogative. An additional evil consists in creating too long a connection with the farm in the case of the outgoing tenant using the barns for thrashing the grain crops during the winter, after quitting the occupation of the land. This is a very fatal objection, as the chief object in the entry to possession of lands and the quitting of farms, is to sever

Times of entry.

Michaelmas very inconvenient.

Must be changed.

every connection as quickly as possible betwixt the outgoer and the incomer, and to make the change so easy and simple as to be scarcely perceptible. The autumn entry is worse than that of the spring, as in the former case, the whole crops of the year are on the ground for conversion and manufacture, while, at the latter term, only a part remains to be consumed of the crops of the former year. On these grounds, both periods of the year are inconvenient for the purpose of taking and quitting the occupation of lands.

A stir is now being made.

The most enlightened judgment and the best practical experience, universally prefer the first of May as the most eligible period of the year, for the purpose of exchanging an old tenancy for a new possession of the soil in the temporary use. At that time, the whole crops of the previous year have been manufactured by the outgoing tenant, and the new crops are only just sown. The labour of the year are also best divided at the beginning of May—the preparation of the ground for the fallow crops of the year is commenced, and the grain crops have been sown by the outgoing tenant on the fallows of the previous season. In this arrangement, the whole manure on the farm that has been made from the straws and root crops of the previous season, belongs to the landlord as the owner of the soil, and through him to the incoming tenant, wholly free of any charge whatever. And the condition is most equitable, that the manures that are produced by any grounds shall be used for their benefit and charged only with the application. The incoming tenant has had the accommodation since 1st of January of the year of entry, of two teams of horses in the stables of the farmery, for the purpose of carrying the dung from the yards to heaps in the fields, where to be used for green crops, and to give the second and third tilths to the lands of the fallow crops of the ensuing year. The outgoing tenant performs the "first" ploughing during the winter, of all the lands to be fallowed in the following year, for which he is paid by the incoming tenant according to the rates of labour in the district. This essential clause in the lease is devised for the purpose of securing to the land the benefit of the pulverization done on the surface of the exposed ground by the winter's frosts and rains, of which no subsequent working of the soil ever can compensate the want. The incoming tenant pays to his predecessor, the amount of the bill of grass seeds which were sown the previous year, and also the expense of sowing them, as he will derive the whole benefit in a crop of hay during the first summer of his occupation. The seeds of the year of his entry, are sown by the teams which are accommodated on the farm previous to his arrival. The grain crops of the year of expiry, are sown by the outgoing tenant, and some two weeks before full maturity, the standing grains are valued by referees, and the sum is paid by the incoming tenant to his predecessor, in ready money, or by a credit accommodation of mutual agreement, when the residences are not very distantly removed. This enactment prevents the crops being parcelled by auction, and carried to distances by much labour, and also the incoming tenant from going to similar occasions, and bringing what quantity he may require at some considerable cost and trouble.

May the best period of entry.

Conditions of it.

Winter ploughing paid for.

Grain crops purchased.

By the above simple arrangement at this period of the year, the quitting connection is the easiest and most thoroughly severed, and the incoming possession is the readiest obtained. On being paid by the new possessor the value of ploughing the fallow lands in the winter furrow, and for the grass seeds of the previous year, the quitting tenant leaves the whole concern without any lag in connection, except the simple operation of having the grain crops valued, and receiving the money, shortly before the full maturity. The incoming tenant on fulfillng these few and simple conditions, obtained at once the free and unfettered possession and use of the houses and lands. There is no mixture of the employments as when the thrashing of crops is one person's, and the cattle in the yards are another's; there are no grounds for brawlings or collisions, in cases of work being done by one man for the benefit of another, when the entry is in the spring or autumn. The connection is cut by an absolute removal of all property on the day of separation, and every settlement is made except in the case of the growing crops of grain, which must wait the period of attained value.

Quitting and entry easy and unconnected.

This general arrangement that has now been detailed, is very generally used in the North of England, and in much of the South of Scotland. The clauses anent the winter ploughing of the fallow lands by the outgoing tenant, and the purchase of the standing grain crops by the new occupier of the farm, have hardly advanced beyond a bare and scarcely pronounced notice. Yet both enactments have been introduced and are now used on the extensive landed estates in Northumberland belonging to the Greenwich Hospital, which are under the enlightened management of John Grey, Esq., Dilston, a gentleman of a very liberal mind, and judicious understanding, and equally eminent in the practice of agriculture, as in the policy of every connection of the art. It is gratifying that our recommendation of both provisions is justified by Mr. Grey's opinion, and sanctioned by his practice.

Mr. Grey's practice.

The arrangements that have been detailed form the prevailing custom over the whole of Scotland, and two-thirds of the extent of England, being adopted and used in the widest meaning by the most extensive landed noblemen of the midland and leading counties. Leases of fourteen years and even of seven years are most prevalent over the southern counties, where the arrangements of entry and quitting of farms are not different in the chief points, and only in the minor details that are occasioned by the locality and established usages. These lesser points are easily gathered from local information, and while the primary regulations are maintained. The very general tendency to adopt on every opportunity the system that has been recommended is the best proof of the superior utility; and the wish that is now expressed to introduce the arrangement where not yet used, shows that the value is appreciated, and that the benefits are known.

Having fixed the term of entry, the lease next mentions the length of its duration in the number of years from the determined period of occupation. The most proper and advantageous length of a lease has been

shown to be twenty years, both for the interest of the landlord and tenant; the former by granting an adequate length of security, gets his property improved, and prosperously managed, and the tenant obtains a period of years, in which to employ his capital and his time, with pleasure and advantage. The time is not at all too long for parting with the control of property, as another person is induced to take an interest in it, which cannot be accomplished by keeping the possession, in perpetually moving from hand to hand, and changing occupiers who have different views, and practise diverging modes of management. A longer period than twenty years has been thought to tend to an alienation of the property, and consequently objectionable; but "issues" by mutual consent could be introduced into long leases, and thus shorten the duration; and the consent of both parties being required to effect a termination, no damage can happen to either party on account of unrepaid expenditure on lands or buildings. But a determined issue of the lease is generally preferred which dates from the time of entry, which are both mentioned in the agreement by the years of the respective periods. It is essential that a lease have the time of issue expressly specified, or it may seem a conveyance of property. It is expedient that the year of expiry be written in the words or figures of the year in which the lease falls, reckoning twenty from the date of entry. Though computation can easily ascertain the term of issue, it is better that the precise time be written, which at once shows the period that is sought.

Twenty years not too long.

A lease must have an issue

The amount of the yearly rent is expressed in one sum, and is most satisfactory in a fixed quantity of money. Corn rents have been adopted, and partially used; but, a very great objection consists in the case of deficient crops imposing a heavy rent on the tenant, when he is least able to pay it, the prices being high and the quantity of grain being small: hence the necessity has arisen, of fixing a "maximum," beyond which the rent shall not rise; as in one single year, of a very deficient crop, the tenant may be irretrievably ruined, unless he have a large capital to support him. On the other hand, the rent to the landlord may be very low, owing to very fruitful seasons, and a "minimum" of the amount becomes necessary to be fixed, below which the rent shall not fall. Two points are thus to be ascertained and fixed, a maximum of rent, and a minimum; and there is just as much difficulty and chance of error, in fixing these two points as extremes, as in fixing a point of medium, or in fixing a certain rent in money. In some few cases of very rich corn-growing districts, this mode of paying rents in a certain quantity of grain valued in money by the average prices of the year, may answer a good end—but grain is not the true measure of rent, which depends very largely upon animal produce of various kinds. The fairness of the above transaction should have neither "maximum" nor "minimum;" and the rent must be regulated, not according to the prices of a single year, but by the average of a certain number of years, in five or seven, so that the fluctuations of rent may not be sudden, but spread over a sufficient period. But even then the

Rent defined.

Fixed in a sum of money.

objection is not removed, of an increase of rent in deficient seasons; for the high prices of that year being included in making the average, raise the sum to be paid by the farmer beyond the general amount of the common returns; and the quantity of grain on which the rent is calculated, cuts heavily into the diminished stock of the farmer, which may be lessened by one third of the usual produce.

Grain rents not generally useful.

A fixed payment in money is the most suitable and satisfactory kind of rent, which is regulated to afford the necessary profits to the farmer, and to bear the occasional deficiencies of produce and the variations of price, which are inseparable from the nature of his business. Every intelligent tenant of land will prefer this calculation of rent to any other system, even of rack rents, which ought never to exist.

Rack rents never to exist.

Payments in kind abolished.

Payments in kind, as in grain, meals, fowls, and in the labour of men and animals, are now nearly abandoned, and should be forthwith exploded. They are the remnants of feudal vassalage and former connection between landlord and tenant, which cannot exist in any emancipated country. The public markets of commodities are free to all classes of society, where sales and purchases are made by fair payments. To these general resorts all parties must go and sell to meet the demand, and purchase by the amount of supply. A bare mention is sufficient as the custom scarcely exists.

Times of paying rents.

The times of paying rent vary much in different parts of the kingdom: but every where the yearly amount is divided into equal halves, and paid at half-yearly periods of time. The most common practice begins the payments at the end of six months after entry, the second payment after the lapse of a similar interval, so that a year's rent is paid during the first year of possession. In North Britain, it is very common to demand no rent till after eighteen months' possession of the farm, and after the farmer has reaped a crop to enable him to meet the demand. In the last way, a smaller capital is required to take a farm of land, as the year's crop pays the year's rent; but at the expiry of the lease, a long connection is maintained between the outgoing tenant, the landlord, and the farm which, as formerly observed, should cease as promptly as possible at one time. The first method requires the first year's rent to be paid from the capital of the tenant, lessened by the proceeds of the animal produce, which has been obtained during the year. This amount may reach the half-year's rent, so that the capital of the farmer has to bear only the rent of the other half-year. At the expiry of the lease, the rent is paid when the farmer quits possession, and the connection wholly ceases. It is the best regulation of paying rents in the due periods of time—the postponement for one year brings into the market an host of speculators, who, at less capital, raise the rents of farms, and ultimately defeat the special purpose. Long usage having established these two periods of payments of rent, and the general capitals of farmers having become suited to the conditions, it matters not much

Long dates at entry to be avoided.

which system is adopted, and the disturbance of either method is not desired to answer any purpose that is seen to be very beneficial.

When the entry to the farm is made in May, the mode of delaying the rent for one year, and the usual credit of six months, fix the first half-yearly payment of rent, at the expiry of eighteen months after the tenant has taken possession of the farm. In this time, he has obtained the year's production of the animal department, and the profits for one and a half years of the grazing stock, which will, no doubt, largely contribute to the payment of the current going expenses of cultivation, and of the domestic establishment. But it makes little provision for the rent of the year—the crop of grain sown by the farmer has been reaped but not manufactured in the month of November, when the first half-year's rent is due in eighteen months after the entry. It is true, that the produce of these crops provides well for the rent of the next half-year, and the proceeds will repay the deficiency of the animal products in meeting the rent of the first half-year, and thus the rent of the whole year is drawn from the farm, without at all trenching on the capital of the farmer, whose funds are thus replenished, but must still make an advance of money as required during the currency of the year; low prices and dull markets may prevent the timeous disposal of the produce, and a deficient crop of grains may demand a store whence to supply any want that is caused by the failure. The farmer may calculate on a somewhat less capital to take a farm by this mode of paying the rent, but not in the full amount of the year's rent, by reason of the accidents that may happen.

One year's delay

makes a long calculation.

When the entry takes place in November, a period of twelve months has elapsed when the first half-year's rent is demanded, in the same month of the following year. The farmer has obtained the proceeds of the animal department for a year, and has reaped "only" the spring crops of grain, as the autumnal wheats are his predecessor's, being sown before he quits possession of the farm. In this point of view little difference is found between the entries of May and November. The possession of the land during the previous summer, enables a better performance of some parts of the cultivation, and is freed of heavy valuations, while it is liable to the greater bustle and inconvenience that is attached to the commencement, than to the fall of the year. As has been observed, the autumn entry is very objectionable, as it brings the whole crops of the year to be arranged and manufactured, after the possession of the farm has passed from the owner of the crops. The Michaelmas entry accumulates a heavy expense on the incoming tenant, the valuation of the unexhausted tillages, the purchase of the outgoing grain crops, if he is bound to do so, and the rent of the year, in half-yearly payments, before any crop has been reaped of his own property, raise an expense that is very unsuitable to the extents of possession and the constitutional value of the lands, and very justly condemn that period of the year as an entry to a farm. The expense is much too great in the first year to be met by ordinary circumstances, and no adequate result attends the arrangement, that cannot be obtained by an easier mode of dealing.

The November entry is similar

and the Michelmas one.

The May entry is least expensive.

The entry on the 1st of May, to which the best preference is given, is by much the least expensive, and by far the most convenient. The first half-year's rent is paid in November of the year of entry, being six months from that date, and gives the summer produce of the animal department to the farmer, wherewith to meet the current expenses, and the first rent, if any surplus remains for that purpose. The amount of the first year's rent enters into the capital necessary to manage the farm, but the payment of the rent regularly as the time progresses, is in keeping with correct business, and at the expiry of the lease the possession of the farm and the payment of rent cease together. This method accords with compact movements and agreeable separations. But an accommodation having been formed for the postponement of the rent till a crop has been reaped, the objections have been much reconciled; but, still giving the preference to the entry in May, rather than in November, on account of the whole crops of the year being at the latter period on the hands of transfer, which causes much unnecessary business and commotion.

and most convenient when the lease expires.

Stipulations of the lease.

The stipulations of the lease condescend to the upholding and preservation of the buildings on the farm, and of the fences and roads, and any other fixed appendages that may be on the lands of occupation. The outgoing tenant is usually bound to keep and leave in good repair, all the fixed utensils of the farm, and the incoming tenant accepts them in that condition, and comes under the same obligation as his predecessor. If the latter party has failed in this part of the contract, the duty falls upon the landlord, that the neglect be repaired by the party who is liable, or that the utensils be put into the proper order, at his own cost, in which the incoming tenant can receive them. The landlord can have the necessary repairs, that have been neglected, to be estimated, and charge the outgoing tenant with the amount. The necessary repairs must always be done by the possessing tenant when seen to be required, and it is the duty of the agent on the estate to inspect the condition of every appendage, examine the stability, and direct the effective maintenance.

When new buildings are to be erected, or extensive alterations to be made, a separate clause in the lease is required for the special case; and when the occurrence happens during the lease, a new agreement is made to suit the business, which is appended to the original document. In these specialties, the performances and obligations of both parties are clearly defined, and distinctly expressed. The tenant receives of the landlord, the raw materials of the repairs.

Support of buildings.

It is a very equitable condition which requires the tenant to uphold the buildings in the same good condition in which he found them, as his fair interest in the use of the houses imposes upon him the very just demand. The extensive and irreparable decays of nature are always excepted—the roof of a house, the doors, walls, and gates, may have lasted beyond the possibility of repair, and no dispute can happen anent the complete restitution. The tenant is frequently held liable for

damage to the buildings by fire—but as the houses are the property of the landowner, equity would direct that the insurance of the buildings be done by the proprietor's cost, and the farmer pays for the security of his own property, which is lodged or manufactured in the erections. A clause in the lease stipulates this arrangement.

The roads, fences, and watercourses are managed on the same conditions. The incoming tenant examines the state of these appendages, and accepts them, and is bound to uphold the suitable condition, and to exhibit it when he quits the farm. If any extensive alteration be arranged, it is specially expressed in the lease, and when a wholly new execution is determined, it is made the subject of a mutual contract, which is singly entertained and expressed. All these arrangements between the contracting parties must, and very easily can, be so pointedly expressed, and easily understood, as never to afford occasion to disagreeable and unseemly disputes. Roads and fences.

The watercourses here mentioned are the beds of small streams that intersect the grounds of the farm, and which at occasional periods will cause damage to the lands by pulling down and carrying away the alluvial banks of the stream. The courses of rivers and of all large bodies of water which rise to the name of brooks, and form the boundaries of estates, or of farms, are the province of the landlord, and are kept in the proper order by his administration. The means that are to be adopted, and the execution of the guards against depredations by unruly bodies of water, will form the matter of a subsequent chapter. The farmer has only to do with occasional torrents of water which intersect his lands, tear the soil, and make a waste of ground. The bed may receive the covered drains of wet grounds, and require a clear discharge at all times, or it may run alongside a fence, and endanger the stability of it, when the outrageous torrent is not securely confined. In these cases the duty of preservation is evidently that of the farmer, but subjected to such assistance from the landlord as will seem to be required from his permanent and future interests in all such matters. In case of any violent and extraordinary accident, the landowner will not refuse the liability of part of the restoration, and sometimes materials rather than labour will be required, and the former may be readily at his command. Strong stakes to be driven into the soft bottom of the torrent, and branches of trees to be woven among the stakes, with the growing end favouring the direction of the water, are very useful materials in the cases of small brooks of water, or slender courses that are liable to be much swollen by heavy rains or sudden thaws, and to become unmanageable by the ordinary confinements. These articles may well be afforded by the landlord, as the strong work that is done will add to the future permanence. The understandings had better be expressed in the lease which relate to such and similar points, and also the exemptions, which are expressly the duty of the landlord, who must be equally bound with the tenant in the mutual obligations. Roads, fences, watercourses, and embankments will undergo a subsequent discussion, and the propriety will Water-courses. Landlord's aid, and in embankments.

be considered of almost wholly relieving the farmer of the charge of any fixed appendages on the farm. A temporary interest ever leads to neglect, which it is the right of the landlord to have redressed, the latter must have an oversight of the former, which might probably be commuted into a beneficial charge, when some necessary arrangements are made to suit the alteration. The hint is merely given here, the adoption remains for the future expediency.

The rules and conditions of management are a very essential branch of the subject of a lease, and have been generally treated at greater length than any of the others, from a belief of its vast importance, and being farthest removed from the knowledge of those persons who pretend to draw the stipulations of the lease of land. In the infancy of improved agriculture, directions and restrictions were not only justifiable, but very imperatively required; but now that agriculture is everywhere known, much less occasion prevails for the use of conditions in the management of land. An extreme liberality has pronounced against any restrictions being imposed upon the exertions of an engagement which promises to do a certain thing upon enjoying a specified privilege, and that upon that thing being done, it matters not how or in what way the privilege be used. To confine the farmer in the sphere of his operations, or to dictate to him a certain course of proceeding in the cultivation of the soil in which he has invested a usu-fructuary interest, resembles prescribing to a maltster how many quarters of barley he must steep in a week, and to a cotton manufacturer how often the spindles must revolve in a day. But the analogy between the two purposes does not hold, as the circumstances of application are wholly different, the farmer and the manufacturer pay rent to the landlord for the use of articles that are very different in nature and constitution, variously adapted, and liable to very opposite susceptibilities. The walls, doors, windows, and roof of the house which covers the manufacturing operations suffer no damage, even from the perpetual motion of the whole machinery that is employed, accidents being excepted, there is no connection between the two parties that can impair the value or constitution by the one preying upon the other. The operations are done by matter working upon matter by means of an intellectual superiority over brute force, there is no vitality employed which requires a sustenation from the powers of another article, and which is damaged by the subtraction of its essence. The employment of the farmer is engaged upon different elements, the produce which he acquires is manufactured by the active powers of life, which are contained and operated in the land for which the rent is paid, and are there excited by artificial processes and applications. A very continued use of the soil in certain purposes is found to deteriorate the quality, and very much to impair the value, and consequently restrictions have been imposed to preserve the value of the original article which forms the property of the landowner. It is, therefore, still necessary, that some rules and restrictions be mentioned in the lease for the purpose of guarding property from spoliation.

Rules of management.

must be specified

are not analogical.

Any directions given to the farmer should relate rather to what he is not to do than to what he is to perform. The end proposed must not be to fetter and control the tenant in the necessary details of his business, but to lay down a few general rules as will lead to some benefit and prevent what is prejudicial. No particular directions are to be given of the labours of the farm, as these duties belong wholly to the farmer himself, but only general stipulations are to be used, which are seen to be of ready observance, and which do not require to be enforced by a useless and injurious interference with the legitimate concerns of the tenant. An imperfectly cultivated country may be much assisted by the directions of a lease, which may be made a powerful instrument for that purpose; but even in that case, general principles and rules of management must show the interest to be pursued, rather than vexatiously disturb and annoy the existing forms of practice.

Forbidding rather than ordering.

Suggesting rather than annoying.

The enlightened knowledge of the present period of agricultural practice renders unnecessary the insertion of details for the use of the farmer, and even the general principles must be few, and which appear to be imperatively necessary and altogether indispensable. In the case of farms that are near to a town, and within the convenient distance of one journey in a day, or of two journeys in the twelve hours of summer, the understanding may be expressed in the lease that the land be cultivated in the course of four years, viz.:—1, fallow or root crops; 2, grain crops; 3, grasses; 4, grains; and then the hay and straw are allowed to be exchanged for half-rotted manure brought from the town in return. This rotation may be continued in the very favoured situations of the best lands, where is an extraneous source of obtaining manures. On the best qualities of soils that are placed beyond the advantages of manure above the quantity made from the yearly crops, the rotation of five years is mentioned in—1, fallow or fallow crops; 2, grain crops; 3, clovers; 4, pasture; 5, grains. With some very few exceptions, this course of cropping may be pronounced to be the most generally suitable for the British isles. On the most inferior cultivated lands, the course of six years becomes very appropriate, as—1, fallow or fallow crops; 2, grain crops; 3 clovers; 4, pasture; 5, pasture; 6, grains. It may be mentioned, that in preparing the grounds for the fallow crops, the land shall receive at least three clean earths, exclusive of the winter ploughing and the drilling of the ground for sowing the seeds of the crops. These clauses may be inserted or omitted, as the circumstances of each special case may seem to require.

General scheme;

but not compulsory:

The farmer must agree not to take two crops of grain in succession from the same ground, and not to mow any grass land for hay twice in the same year. Any fields of grass land that are of very superior quality, must be designated by name to be kept in that condition of use, and to be mown or pastured, as circumstances may require, and without any provision in the lease for that purpose; but no restrictions must be imposed on the tenant breaking up and using as arable grounds all inferior grass lands, which at present yield chiefly very scanty crops of weeds and mosses. It may be

varied by circumstances.

mentioned, that all hays and straws are to be consumed on the farm, except in the vicinity of towns, when a special arrangement provides for the alienation by an express clause in the lease. Hay is in some cases allowed to be sold, and straw is prohibited; potatoes are sold everywhere, but turnips must be consumed on the farm. These variations are guided by the peculiar circumstances in which the location of the land exists.

These and similar rules of general adaptation are as few in number as possible, in order that the farmer may not be converted into a mere machine, the action of which is altogether directed by an external application.

"Good husbandry defined."

The much criticised words, "by the rules of good husbandry," are appropriate enough, and sufficiently intelligible, and mean that all the performances of cultivation shall be done in the best and most approved methods. These operations are well understood in the present day of practical farming. In the courses of cropping that have been mentioned, one-fourth, one-fifth, and one-sixth part of the arable lands will be yearly fallowed, as shown by the number of years in the rotation. In the end of the lease the tenant must not depart from the course of cultivation that has prevailed during the currency of the lease, and a clause is made to contain this enactment, in order that the land is not scourged by severe cropping to fill the pockets of the outgoing tenant. The interests of the landlord and farmer are certainly the same in reality, but they do somewhat differ in the latter years of the lease when the farm is to be quitted; and fair dealing requires that no interest shall abuse the other; and there can be no hardship in binding the tenant to continue to the end of the lease the system which he has reckoned to be the best for his own interest. A sufficient guarantee of good management does not invariably lodge in the interest of the tenant, the circumstances of his position may be widely changed during an extended term of years, and the landlord must not be injured by the casualties or contingencies that may happen to the private means of the tenant. Public property should not suffer from private accidents.

Last years of tenure.

The root crops and the hay of the previous year will be wholly consumed by the first of May, or the time of entry; but part of the straw will be remaining in a thrashed state, and all the dung made in the cattle yards during winter will be on the ground, and best carried out to heaps near to the fields to which it will be applied. These unapplied productions belong to the farm, and are used by the incoming tenant free of any charge; but a tenant right of three years is given for the unexpired value of artificial manures, as bones and guano, which are extraneous to the farm, and require a separate consideration. The remaining benefit in one or two years is valued by referees, and paid by the incoming tenant.

Dung and straw go free.

Artificial manures have a right of 3 years.

When three crops have been got since the application of the manure, the right of compensation ceases. This enactment has been introduced on the extensive estates of the Greenwich Hospital, in Northumberland, under the direction of John Grey, Esq., Dilston, whom we have before mentioned, as the agent on that property. It is a

most equitable stipulation, as it does not hinder the tenant from making useful applications, even when he knows he quits the farm from the dread of losing the full value by the removal. By getting no value for the farm-yard dung, he does not lose any thing, as he gets the same conditions on the farm to which he removes; but there may not be any artificial manures in use, and no benefit can be derived from them. Hence the extra application of artificial manures requires a separate consideration, and are justly entitled to the above recompense. Even under a lease, the liability does not cease, as it has an issue, just as tenancy at will expires on a due notice being given.

Mr. Grey's practices.

The landlord reserves for his own use, and witholds from the occupier of the surface, the workable minerals, as metals, coals and limestone: clay may be added, when the quality of it suit the use in making bricks and tiles. The farmer is paid for any surface damage that may be done, by the award of arbitrators, as it cannot be known at the time of negotiating the lease. Growing wood of all kinds belong to the landlord, with the provisions of felling and pruning the trees, and carrying away the produce. All woodlands enclosed or unenclosed, are the landlord's reservation, which is not abandoned by the pasturage being used by the farmer. But the lease must expressly mention the special rights in these cases. A power is sometimes reserved of taking, to be planted with trees during the lease, any quantity of ground, on the tenant being abated in the rent for the estimated value. The rent of one and a half years is generally deducted, as a set-off for the inconvenience of losing probably an undue quantity of land, or at least an unexpected choice of the bereavement. It is best when the landlord reserves at once from the lease, some fixed quantity of lands to be resumed at any time, and merely defers his power to do so to a convenient time. Uncertain reservations often lead to misunderstandings and disputes.

Woods and Minerals.

The right of the landlord to shoot, hunt, fish, and fowl, on the lands let to the farmer, is generally understood to be of common law, but is best expressly mentioned in the lease. The keeping of extensive and thickly stocked preserves of game animals, is quite a different subject from walking over grounds in search of the stray birds that alight upon the surface from hunger, or from being wearied on the wing: the former case requires that the cultivated lands which surround the preserves, be used by the landowners themselves, the damage done to the crops by the animals will fall upon the proper quarter, and complaints and bickerings will be removed. In common cases of the open farms at a distance from the seats of landowners, the right to shoot the four-footed animals might be given to the farmer, reserving to the landlord the privilege of murdering the winged tenants of the air. Some such arrangement might lead to a settlement or a lull of the vexatious question of game, and damage to growing crops. The right is not likely to be relinquished by the owner of the soil, and therefore should be accommodated.

Hunting and Fishing; shooting accommodated.

The insertion of a clause is quite harmless that the landlord or his agents have a power, at any time, to enter the grounds and see that the

conditions are complied with. Such a power must evidently be understood; but a clause to that effect is generally inserted.

The rights of the contracting parties are capable of being determined by common law, but are generally fixed and explained by the terms of the agreement. The farmer and his heirs hold the lease during the stipulated time, on the conditions being fulfilled which were laid down in the contract. A lease of land is an heritable subject, and in case of intestacy, goes to the heir-at-law: and in England the deed excludes subtenants, but is directed to heirs and assigns, without any molestation from the landlord. In Scotland, not only are subtenants excluded, but likewise assignees, legal or voluntary, inferring that the lease shall go to the heir-at-law alone. This rigid destination of the lease, does not answer any purpose of utility: it is intended to give to the landlord the choice of a tenant on the death of the original occupier.

Lease is heritable.

During the currency of the lease, the farm may pass into the hands of distant heirs, of whom the landlord can know nothing, or into the hands of guardians or other legal managers, that are altogether unknown to him. The "electus personæ," or the choice of the person who shall occupy his property, has been much insisted upon, as the privilege of the landowner; and it has led to the nomination in the lease of the parties who shall inherit the farm in the case of changes occurring in the natural lives of the occupiers. But even with these provisions, the landlord does not obtain the certainty that the heir of the lease, who may be then unborn, shall choose the farming profession, and be qualified to conduct the cultivation of land; nor does he know that the specified members of the family will undertake the conditions of the lease, with the willingness and ardour that are requisite to ensure success in any undertaking. The heir-at-law, or the eldest son, may be prevented by circumstances from becoming a farmer, he may be the least qualified member of the family, and various causes may render him unfit for the intended occupation. The farmer has no power to rectify the evil, by making any other assignation; but there may be some advantage in getting the eldest son trained to agriculture as a profession from childhood, from being regarded as the heir of the lease. Though not many practical inconveniences result from the established custom, the tenant may, without any damage on the opposite side, have the power of devising his lease as any other part of property.

Should not be strictly applied:

might be devised by the tenant.

The choice of a tenant or temporary occupier of land, involves several points of very grave consideration. The customary acuteness of the Roman people did not overlook the qualifications that should attend the amenable cultivator of the soil—for Columella in the book "De Re Rustica," expressly says, that the occupier should be a person "qui sciet, qui poterit, et volet," or one who knows how to do the business, who has the means of doing it, and who has the willing ardour to perform the duties of the undertaking. The professional knowledge of the offering person must be very strictly regarded, and a satisfaction on this point must be obtained before any advances are made to the other points of ad-

Choice of a tenant.

justment. Ample recommendations must be got of his capability on this head, from quarters that set aside any expressed doubts. Ignorance will ruin any property, and render of no avail all the safeguards which a lease can contain. It may appear a very inquisitorial sort of business, but there seems to be a necessity, that the landowner shall know the means that are possessed by the offering tenant, to enable him to cultivate the land in the most approved practice of agriculture. Extensive damages have accrued to the owners of the soil, and heavy losses and large inconveniences have attached to the cultivators themselves, from the perpetual desire of grasping more in the hands than can be firmly held, and of extending the sphere of operations much beyond the means of the proper accomplishment. Expansion will ever be much weaker than compression, and combination of force, of any kind, has ever been attended with magical results, when directed by the legitimate comprehension of its value. The owner of the soil is entitled to have some understanding on this head—a correct statement of means need not be requested—but a gross estimate may be offered, and confirmed by the proper marks of validity. The capital required will vary from £6 to £10 per acre, according to the circumstances of the price of commodities, and the condition of the farm as arable or grazing grounds. Of the whole amount of capital, at least one-fourth part must be reserved in store as a fund at interest for the purpose of meeting the demands of accidents, and unexpected contingencies. Casualties of every kind must be supplied by the reserves, which must be ready at command when wanted, promptly administered, and of sufficient power to fill the gap and repair the disaster. No prudent director of a considerable amount of power of any kind, ever expends the whole amount in the first effort—a part is always reserved to assist the points that may fail from unexpected resistance, and to supply the wants that may occur, and the accidents that may happen. Many enterprises miscarry from want of this reserve—and farming being exposed to many contingencies, requires such a provision as much as any undertaking of action. Of all the evils that can affect the farmer, none is more to be dreaded, or more pernicious, than the want of the requisite funds, and of a reserved capital: without a sufficient amount of means, every effort is vain and delusive—the absence of the prime mover sinks every knowledge, and destroys all the attempts of an eager progression. The landlord is damaged in his property, and the public are despoiled the legitimate inheritance in the production of the necessaries of life. Labour is robbed of its patrimony, in not being employed to the due extent, and the formation and accumulation of capital are stopped at the very fountain head.

Means should be known.

Capital required.

Reserved capital.

There is also required in a farmer, the wish and the willingness, to do the business in the proper manner; the ardour which creates the zealous emulation, and the enthusiasm which renders success to be certain in any undertaking. A sluggish, mindless plodding, must if possible be avoided, which neglects the opportunities that may be liberally offered in the due security of tenure, the very full and adequate

Necessary willingness.

provision of fixed capital, on which the floating funds of the farmer are used in the permanent appendages that have been before mentioned, and the compliance, on the part of the landlord, with every reasonable demand that is made by the tenant, on his means and his liberal consideration. The farmer should possess an eager desire to enter into these views, and to advantage himself, by the use of the endowments which are seen to exist, and which may in future be granted. The landlord has a right to be satisfied on these points, as far as enquiry can lead to an opinion.

Expired leases. When land is out of lease, the general rule should be to treat with the tenant in possession. He is acquainted with the farm, and attached to it by habit, and some one of his family or relations may look on the farm and the lease as their descending patrimony. The feelings of old age and of infancy are torn asunder, by the dispossession of the old tenant, and doubts and fears may darken the later years of life. Violence is required to break the long association which even the respect of place winds round the heart, and the pangs of separation are many and acute. Cases will arise which forbid the treating with the old tenant—he may be superannuated, or has been a slovenly cultivator, and has neglected the opportunities that have been offered. Then another person must be sought by private acquaintance, or by advertising.

When to be renewed. The treaty with the tenant in possession, when circumstances are suitable, should be ended two or three years before the old lease expires, as it removes any inducement to scourge the land by cropping, the ordinary management is uninterrupted, and the land is better treated than if the lease had expired. The old tenant is generally preferred to give the full value of the land, which his experience will warrant. He will be easier treated with than a stranger on matters of new outlay, and any requirements that are made, will be more speedily adjusted with him, than in the case of a new possessor, who will see more wants, and require more accommodation. The troublesome conditions will be avoided which attend all changes, even when done under the easiest and least intrusive conditions. This fact carries with it some very considerable weight, on the subject of letting farms that are out of lease.

Advertising of farms. When any farm is wholly voided by the late possession, an advertisement may be made of the opportunity of negotiation, for its use, but no auction should ever be allowed to the highest bidder. Not the promise of a rent is to be regarded; but the skill, capital, and character of the tenant, are the chief considerations, and must be found in existence, or very serious losses will happen to the owners of the soil, as have already been witnessed in a large abundance. The promise of a very high rent argues an ignorance of the business, or that no loss can be sustained; and no evils that can attach to landed property, have inflicted more serious and lasting damage, than the want of skill and funds by the tenant. By treating with private offers, the landlord secures the choice of a tenant, and deserving persons have the means afforded them of procuring farms. The character and circumstances of the offerers can be privately ascertained, and a general comparison effected—and it will be learned

if the most likely person that offers is known to exert his professional skill and his means with an enthusiastic discretion, and if in his private capacity and social relationship as a man, he maintains the dignity of human nature, as a responsible moral agent. These observations do not at all tend to introduce any political or religious distinctions—those views are wholly beyond the subject—but the special duties that devolve on landed property along with its rights, render it imperative that there be upheld by its station, a careful and nicely scrutinized selection from the broad phase of human nature, of the agents that are to perform every important subordinate part in the large operation of fulfilling the mighty scheme of nature's grand intent. The general course of human nature demands the provision of the above-mentioned qualities in the station that, is occupied by the farmer, of capital and intelligence.

Extraneous avoidances.

The persons are generally mentioned in a lease of land, who are agreed by the landlord and tenant, to succeed in the occupation of the farm, in case of the lapse of one or more lives, during the currency of the period of tenure. These provisions very frequently give the lease to some person, who may think it a very troublesome incumbrance, being bred to, and occupied in, a wholly different branch of business, and he has no power to assign it or give it to another person. He is compelled to perform the occupation, and whether he succeeds or fails, he must implement the conditions of the lease. The eldest son, or some younger member of the family, may be bred to farming, with the express view of inheriting the lease; and in that case, the lease may provide, that the farm be transferred to a specially educated son of the farmer, and in default of his life to a similarly qualified member of the relations of the family. The farmer, no doubt, should have the power of devising the lease as any other property—but though the lease be heritable, the property in it is not absolute, but fettered with conditions, that relate to other interests, which must be taken into account, and legitimately considered. It is most equitable and just, that an assignation of the lease have the consent of the landlord, and that he be consulted in any intention of changing the temporary proprietorship of the land. His own interests will not, or should not, compel an unwilling occupation by an incompetent person, and no damage can result to the family of the farmer, from the friendly interference of the landlord in settling the affairs of a decease. The words of the lease may allow the farmer to demise the property to the most qualified son or member of the family—and in case of another vacancy, it shall go to the next heir who may appear the most eligible, the heir-at-law being always in reserve, to step in and settle any interminable disputes. If these directions are thought too vague, and not sufficiently precise, the lease may be held to be devisable, as any other property in case of the death of the first holder, and to be assignable by any living possessor of it with the consent of the proprietor of the land.

Succession in the lease: assignation of it.

The bankruptcy of the tenant must be held as an "ipso facto" irritancy of the lease, which will expire the first of May that follows the event, and the same obligations must be done on

Bankruptcy voids the tenure.

both sides as are prescribed for the last year of the natural termination of the agreement. No creditors must be allowed to enter upon the farm, in any way, for the purpose of reimbursing themselves by a lease of the property—the moveable goods only are liable for debts, the heritable are beyond the power of seizure. The farm is vacant, and to be relet, or granted in possession to the family of the farmer, as circumstances may direct. The landlord in that case must see a suitable person to continue the farm, and be satisfied that sufficient means exist for that purpose—otherwise a new tenant must be found.

A new tenant found.

Sketch of a lease.

The following sketch of a lease is drawn from the principles that have been stated, and contains the chief points of agreement, to which may be added the additional clauses which may be rendered necessary by local and adventitious causes.

A. B. lets, and C. D. accepts, in lease for the period of twenty years, from 1st of May 18 ——, the farm of land known by the name of ————————, and situated in the parish of ————————, and consisting of —— acres, or thereby, partly in grass, and mostly in arable grounds. A. B. warrants to C. D., the free and unmolested possession and use of the lands for the time specified, against all intrusion whatsomever. A. B. reserves as his own property, all the standing timbers on said farm, whether contained in the enclosed plantations, or standing by the sides of roads or growing in hedge-rows, with liberty to approach, cut, fell, sell, and deliver, the said trees or timber at the proper season of the year. All workable minerals below ground, as lime, coals, clay, and metals, are the property of A. B., and may be used by him at any time on allowing to C. D. the valued arbitration of the damage done to the surface by the operations of mining. A. B. has the liberty of shooting and fishing over the grounds thus let (in the proper seasons,) and by other persons to whom he may give the permission. A. B. restricts the quantity of game as not to visibly damage the farmer's crops.

A. B. engages to uphold and maintain in proper condition, all the fences of plantations which are now formed, or may be afterwards made, and also to give to C. D. at the place of manufacture, the raw materials, as felled timber, lime, bricks, and stones, that may be required during the currency of the lease for the purpose of repairing the partial decays of the farm buildings, gates, and fences.

Obligations.

On the other hand, C. D. binds and obliges himself, his heirs, and assignees, to give for the use of said lands, the yearly amount of £—— in money; and to be paid to A. B., in equal halves of half-yearly payments, the first being at the expiry of six months after the term of entry, and to continue at the end of every six months for the term of the lease; C. D. agrees to pay to the outgoing tenant the value of ploughing in the winter furrow the lands intended to be fallowed during summer, which will be fixed by referees, according to the price of labour in the district. He also agrees to buy from the outgoing tenant, the whole standing crops of grain in the beginning of maturity, which will be valued by two persons mutually chosen, with an umpire whose decision shall be final. He also pays to the outgoing tenant the price of the grass seeds

Performances.

that were sown the spring before his entry, and of the attendant labour. He pays the unexpired value of auxiliary manures, as bones and guano, but nothing for farm-yard dung.

C. D. engages that during the currency of the lease, the arable lands shall be cultivated by the most approved rules of husbandry, with the observance of the following special conditions. Two crops of grain shall not be grown on the same lands in two successive years, and no grass lands shall be mown twice for hay in the same year; one fourth, one fifth, or one sixth part of the lands shall be in fallow preparation yearly, according as the course of four, five, or six years, be adopted as the rotation of cropping, and the same quantity will be left in the last year of the lease. C. D. accepts the present condition of the farm buildings, fences, gates, and roads, and engages to uphold them all in proper order throughout the lease, and to leave the same condition of these appendages at the termination of his tenure: he engages not to fell any timber, or growing trees, and not to shoot or destroy any game animals, except by the express permission of the landlord. In the case of draining wet lands, C. D. agrees to perform all carriage work that may be required, and to pay 5*s.* an acre for the drained grounds, along with the rent in half-yearly payments. And also the carriage work for any new buildings that may be agreed to have erected during the lease by a special agreement: C. D. engages not to sublet any part of the lands that are in his temporary occupation, and designates as his successor in the lease, the eldest son [or any other son,] who may be trained to the business; and in case of accident or non-acceptance in any case, the lease to be assignable with the consent of the landlord. Observances.

If C. D. quits the farm at the specified termination on 1st of May, 18—, he engages to quit the possession at that date without any legal notice or warning whatever. He leaves, as he received at the entry, the remaining straw and dung in the yards during winter, to the incoming tenant free of any charge—he will be paid for unexpired value of manures as he did on entry; for winter ploughing the fallow lands, and for the grass seeds of the foregoing spring. His grain crops will be valued before maturity, and the amount paid to him by the incoming tenant. He gives stable room to two pair of horses, after 1st of January, as he received on entering. Quit duties.

Signed this —— day of ————————————, 18—.

Witnesses, { A. B. / C. D.

The chief attention in the form of a lease, is simplicity and conciseness, avoiding all multiplicity and complexity of detail, and making the conception of it to be ready to any understanding, and the performance easy to every knowledge of execution. The above mode of entry and arrangements renders almost imperceptible any change in the tenancy of the land, and approaches to the much desired perpetuity of occupation. Such a holding, or the nearest possible similarity to it, is required for the benefit of the property, and of all parties concerned. The granting of such a thing becomes a pleasure, and the acceptance of it, a tribute of willing respect. Specialties of a lease.

CHAPTER III.

CULTIVATION OF LAND, AND ROTATION OF CROPS.

Cultivation defined.

CULTIVATION is the art of tilling, preparing, and improving the soil by means of labour and manure, so as to render it in a fit condition for affording plentiful crops, according to the nature of the climate, situation, and other circumstances in which it is placed. It includes tillage, in all its branches, in the cultivation of arable lands; the application of manures on the prepared grounds; the use, sowing, and reaping of particular crops; and the management of grass lands. But it is more particularly applied to the preparation of the soil by the implements of culture, which fits the ground to receive the seeds, and produce the respective crops. The working of land by the implements and manual labour, along with the kinds and order of plants which are used for crops, will sufficiently comprehend the sphere of cultivation, accompanied by a notice of the mode of applying the special manures for the different plants that are used.

Notices to be made.

In the present state of agricultural practice, the operations of cultivation begin after the harvest of the year has been finished, with the view of the next year's preparations. In Britain, the crops are secured in the months of August and September, and protracted into October in the northern parts of the kingdom. The change of season, and the autumnal rains will have softened the land into a ploughable condition by the month of November, when the stubble grounds, for the fallows of next year, are ploughed with furrow of seven or eight inches in depth. The power of two horses will suffice for the light lands of all kinds; three will be necessary for heavy stiff loams, and four are required to plough the obdurate clays, as the plastic and London formations. The three horses are yoked on the principle of the steelyard; two animals walk in the furrow in tandem, the foremost drawing from the back shoulder of the hind one, by the common chains, lengthened by the stretcher chains of the two-horse cart; the third horse walks on the unploughed land, and is made equal to the two in the furrow, by being yoked to the long end of the main-tree of draught, which gives an advantage of the power of an animal by means of the point of centre being one foot removed to the end by which the two horses are attached. A lad is required to drive the animals, which form a very strong team for ploughing. Four horses in a plough are yoked as the two in the furrow, as above-mentioned, and are driven by a lad, or stout boy. It is essential that the winter ploughing of land be deeply done, in order to afford abundance of loose soil for the operations of the next summer and spring. An early and deep

Winter ploughing.

winter ploughing produces a tilth, and imparts a mellowness to the soil, which late ploughed lands never acquire, and is never to be obtained by any subsequent workings of the ground. The condition remains cloddy, rough, and clammy; and the soil never falls from the implements, till the approach of autumn weakens the adhesion of the particles by diminishing the contraction of the clayey constituents. With sands and light loams, the matter is not so very great, but all lands are better in being early ploughed, in November, December, and not extending far into January. Turnip lands are ploughed in breadths of many yards, as the soil is dry, and no attention is required to the direction of the surface water. But clay lands that are summer fallowed for wheat, are laid into ridges of four to eight yards, and the furrows are cleanly opened that the water may freely escape. The ridges may be cleaved by the ploughing, or cast in two or four together; in either way the furrows are kept open and cleaned out by the plough. This method retains the furrows in the present position and form, and is called casting to the gore furrow; two ridges are gathered, and two are cleaved, and makes a work of much neatness. When the ridges are high in the middle, each single one may be cleaved out in the winter ploughing—the accumulation of soil in the centre is exposed to the atmosphere, and the gathering of the ridge is facilitated for being sown with the seeds in autumn. Where the whole field is ploughed, the headlands must be cleared; and the inside furrow, which receives the water from the longitudinal furrows of the field, must be deeply and cleanly drawn by the plough, in order that the water may quickly escape, which requires a cut made by the spade from the ends of the furrow into the side ditch of the field. Headlands should not be under six yards in width, in order to give ample room to the ploughs in turning, and to avoid the land being trampled by the horses after it is ploughed, a most unpardonable blunder in the art of ploughing, besides the damage done to the land by the prints of the feet of the animals holding water during winter, and starving the roots of the wheat plants. It is a rule in the management of clay-lands, that no hollow or stoppage be allowed in which water can lodge, but that the furrows are clean of earths or clods, and that the corners of the fields have open cuts made by the spade from the furrows into the land ditches. In the ploughing of all lands, and more especially of clay soils, honest work must be done, or the furrows must be cleanly moved from below, laid at the same height, and be of a uniform width and depth. No unmoved land, or "rafters," must remain between the furrows, nor any flat position, nor the standing on edge of the slices from the plough. The edge of the furrow that is cut by the coulter and share must be placed quite perpendicular, and the same position must be preserved throughout the whole work.

Modes of ploughing:

must be neat and honest.

The average of spring seasons will mostly permit the second tilth of winter ploughed lands to be done in the end of March, or during the month of April. The ploughing is performed at right angles to the first furrow, or straight across the field; in some cases the ridges are singly cloven by the spring ploughing, but it is inferior to a cross plough-

Spring ploughing.

ing in effecting the required purpose. In cross ploughing clay soils, it is essentially necessary that narrow furrows be used, in order that the land be completely stirred, and none be left unmoved between the furrows. The furrow must be to the depth, or even deeper than the winter ploughing, that abundance of soil be raised for the future operations. If the land be very wet, the furrows must be opened by the longitudinal operation of the common plough, after the cross ploughing is finished. In some places the cross ploughing of wet clays is never done, but the lands are wholly tilled by ploughing longitudinally, from dread of heavy deluges of rain, inundating the land when all the furrows for the discharge of the water are choked up. The working of the land is not so complete as by cross ploughing, but the alternative is preferred.

Best cross-wise.

Previous to the cross-ploughing being commenced, a skilful ploughman is sent on a day or two previous, for the purpose of drawing straight furrows across the field at the distance of twenty to thirty yards from the continuous divisions. These furrows serve as marks to the ploughs when the work is begun, and no time is lost by looking for directions to the process. The marking plough goes and returns in the same furrow, and throws out an open space in which the ploughing begins, and maintains a level work on the surface of the ground. The two furrows of the commencement of cross ploughing are laid together as a turnip drill, which is readily done in the widely opened mark by the plough—a narrow comb thrown up at the commencement of any ploughing, forms a blot on any pretensions to skill in the art. The open furrows made in the spaces of cross ploughing by the termination of the work, are to be filled up by ploughing in reverse for three or four turns of the plough. This reversal prevents any opening to remain after the land is harrowed and rolled.

Harrowing and rolling.

The state of the land and of the weather will direct the application of the harrows or of the roll, in the first use of the implements. In dry seasons, and on hard viscous clays, the harrows will be unable to make any impression, and the roll must be used, even if four horses are required to draw it. But the cost must not prevent the most important purpose of reducing to dust, during dry weather, the hardened clods of clay, and the masses of soil that are often produced by cross ploughing. On soft clays, and in moist seasons, the harrows may be immediately applied, when, with the intervening assistance of the roll, the land will be reduced and pulverized, and weeds will be extracted.

The first operation.

The weeds and stones that this first operation is capable of eradicating must be without delay gathered by hand, and carried away from the field. Little delay must occur in performing these operations. In mild showery seasons, the weeds will quickly revive and show a green appearance, of which no vestige must be allowed during the process of the arable cultivation of land. The last harrowing of the land and the picking of the weeds may go on simultaneously, and be nearly finished together. The farm should possess a sufficient quantity of strength to enable the furtherance in conjunction of the processes of action that are nearly allied in the performance;

the close connection must be studied, and the regulations correspondingly adapted.

In the end of May, or in the first part of the month of June, the land is again ploughed, and done longitudinally, in casting together two or four ridges, and keeping open the furrows as the ploughing is performed. The surface is immediately harrowed, rolled, and harrowed again, and the weeds and stones are gathered by hand and removed from the field. This operation constitutes the second cleansing process, and puts the land into a good cultivated state. When the soil is a friable clay, and not excessively hard and stubborn, the above ploughing may be deferred for a time, in order to make the next furrow be the bed of the dung and lime. But where weeds abound, or the land is very stiff and viscous, another ploughing is given in the end of July, when the ground is harrowed, rolled, and harrowed, and cleaned of stones and weeds as before. This furrow reverses the last ploughing by throwing the ridges in the contrary direction. The land will now be ready to receive the lime, if any be applied, which is carried to the field in hot cinders, and laid on the ground in heaps of one to two bushels on a square perch, or a space of six yards by five. The quantity used on an acre will regulate the size of the heaps, but one to two bushels is the common average. A man with a shovel must be employed to lay the heaps in a neat form, and cover them with earth, the moisture of which will gradually reduce the cinders to powder. When this reduction is effected, the whole of the heaps must be regularly and evenly spread over the surface of the land, and immediately covered by a double tine of harrowing. The process of spreading and of harrowing the lime must go on together, by a combined arrangement, as a high wind will blow away the lime if left spread and uncovered.

Subsequent operations.

Use of lime in one way;

Another method lays the cinders of lime in a longitudinal heap on the headland of the field where it is slowly turned over, and at the same time dissolved into powder by the application of water; in this powdered state it is carried to the field, and spread from the carts with shovels, in the space of one ridge, with the cart moving along the centre. The quantity applied must be regulated by the eye of the master in the thickness of the strewing on the ground. A new method directs the hot cinders to be scattered over the ground, and covered by the ploughing, when the moisture in the soil will dissolve the shells, and the land will derive much benefit by the damp exhalations of heat that are evolved during the dissolution of the cinders. As the powder will lie underground in lumps, a future working of the land must be understood in order to spread abroad the lime that is dissolved, and in at least two operations done lengthwise and across the field. This necessity demands an earlier application of the lime during the second stirring of the land in the month of June. When the application is properly done at this period of the year, and the subsequent workings of the land are seen to spread the powdered lime in the soil, this mode of applying calcareous manure must be very superior

in another way;

by burying the hot cinders.

to any other, as the caloric evolved by the hot cinders during the dissolution will penetrate the body of clay, sunder the particles, break the texture, and pulverize the whole mass. It will also impart to the ground a higher degree of temperature than it before enjoyed, which is the mode by which lime communicates any benefit to the land.

Dung applied in broad cast:

So soon as the process of liming is performed, the dunging of the land may commence. The heap of dung may be in the field, having been carted to it during winter, or it may be at the homestead, having been turned over in the yards. The dung is laid from carts in small heaps on the ground, and in a row along the single ridges of land; it is immediately spread evenly over the surface, and covered by the ploughing of the ground. The dung must be well broken from lumps, and scattered in small pieces over the surface, and must lie uncovered for as short time as possible. Farmers who entertain nice ideas on the subject of evaporation and loss by exposing dung on the ground to atmospheric influence, appoint a woman or lad to follow each plough, and with a light fork to throw into the furrow any lumps or clods of dung that are pushed before the plough, and lie uncovered. This simple precaution prevents any rough dung being exposed to view, renders the work more complete, and is fairly worth the expense, though the principle of loss by exposure yet remains to be proved.

A method has lately been adopted by drilling the land with one furrow of the common plough, and laying the dung in the furrows. The plough makes a drill by one furrow or rut in going the length of the field; the dung is laid and spread along the hollows, the plough in returning covers a drill of dung with one furrow, and the land presents the appearance of being ridged with green crops. This method is superior to the broad cast plan in covering the dung; and drilling the land is less work than ploughing across. Harrowing will be required to level the drills before the land is ploughed for being sown.

by drilling.

In ploughing the land this time, some attention is required that the furrows are neatly ploughed out as the season is advancing, and floods of rain may be expected; the two last furrows on each side of the closing being always done by a plough drawn by two horses walking in "tandem," in order that the horses may not walk upon and damage the ploughed land. It should be managed by a skilful ploughman, and the closing water furrow should be deep and narrow to suit the plough that draws the furrow afresh after the land is seeded. A wide, open, gaping furrow with flat sides is a great deformity in finished work: it is often seen, but is not the less reprehensible on that account. The headlands being neatly gathered up by the plough, the cuts at the ends and corners must be opened into the ditches, and in this state the land waits the seed furrowing after harvest.

Sowing of wheat.

The month of October is the general season of sowing wheat in Britain, when the land is neatly ploughed by one furrow and the ridges gathered. The seed is sown by broad cast or by drill machine, the water furrows are drawn by the plough, and the cuts made by the spade

when the process of cultivation is finished, which was begun about the same period of the previous year.

A very considerable part of the clay lands in England are lying in ridges of a crooked serpentine form, of unequal widths at the ends, and often terminate in a point in the middle of the field. The working of the land in consequence becomes very awkward; and many attempts have been made to straighten the ridges, and in some cases successfully, from the ridges not being very high nor very crooked, but in many attempts with very great damage, from the contrary circumstances of height and shape. By reason of the long continued gathering of the ridges in the olden mode of cultivation, the subsoil has become convex as well as the upper soil, and when a newly made ridge took a slanting or crossing direction over these convexities, the water lodged in the hollows, and reduced the full half of the land to a state of mortar: much loss was in many cases sustained, and the failures had the usual effect of deterring other attempts where the same obstacles did not exist. It has been recommended to make a complete alteration at once by a levelling with the spade, removing the too high subsoil to the lower places and then replacing the top soil; but this expense would in many cases exceed the value of the land, and has been little used. When the ridges are not very high nor very crooked, the alteration is easily effected by the plough, and the harrows filling up the hollow places; and in extreme cases a very safe method consists in making with the plough a narrow ridge of four or six feet in width in the old deep furrows, and increasing it in breadth every following course of fallowing till it rises and fills the hollows, and levels the high ridges, when the new ridges may be drawn as nearly as possible in the direction of the old ones, and then the water will obtain a gradual flow. This method may be reckoned slow, but it is the safest and most convenient yet practised, being wholly done by the common plough.

Crooked ridges made straight.

Turnips may be raised on any clay soils in the following way. The land may be wrought in the usual method into July by three ploughings and harrowings, when the dung is applied in broad cast, and the ridges are gathered by the ploughing. The surface is harrowed to the utmost possible fineness of tilth, when the turnip seed is sown in broadcast, or by a drill with long coulters which make ruts in the ground, and form the crop into rows. The hoeing of the turnips is done in the usual way. It is supposed that clay lands will produce turnips by this treatment, or some similar cultivation. The turnips grown on lands pared and burned without being ploughed, show that the root of the plant does not require a finely reduced body of soil, provided the surface is pulverized to the degree that induces the early vegetation and growth of the tender plant. The encouragement that is given on the surface of the ground seems to secure the growth of the plant.

Turnips on clay lands.

Green crop lands require the same early ploughing in winter as clay soils, in the months of November, December, and January. The furrow must be round in form and square in the cut, and to the depth of seven or eight inches where the soil will possibly allow. Stiff

Turnip lands.

loams may require the power of three horses to move the required depth of soil. The average of seasons usually allows the second ploughing or the cross furrow to be done in the end of March, or early in April, when the furrow slices must be narrow, so as to leave no unmoved ground betwixt the motions of the plough, and that the earth turned over may not lie in very large masses. A day or two previous to the ploughing being commenced, a skilful ploughman is sent with poles to mark out the field into spaces of twenty to thirty yards, which are made by a furrow of the common plough, moving twice in the mark that is made. This provision affords a ready beginning of work, when a number of ploughs are sent to the field. When the spaces of ground are finished in the ploughing, the open furrows are filled to the level of the surface by the furrows being reversed on each side in the extent of two or three yards. The harrowing is immediately done and repeated till the clods of land pass between the teeth of the harrows without being broken, the roll follows in one application, and the harrows are again used to tear the weeds and pulverize the squeezed clods. The three processes in the first harrowing, the rolling, and the second harrowing, may proceed together; and the hand-picking of stones and weeds can also accompany the operations. These nuisances are removed from the fields by carts very soon after being gathered into heaps. The next ploughing is done lengthwise, and in breadths of about thirty yards as before, and will be finished by the end of April. The same rolling and harrowing, and picking of stones and weeds are done as before, when the state of the land will show if the soil be fitted to be planted with potatoes; if not, another ploughing must be given without delay. The potato ground should be ready in the third week of April, when the land is opened into drills of thirty inches apart by one deep furrow of the common plough. The half-rotted dung of the farm yards is placed in the intervals, and evenly spread along by light forks in the hands of women and lads, who are superintended by a trustworthy man of the farm. The sets of potatoes fresh cut are carefully placed by hand over the dung at the distance of eight or nine inches apart, and pressed into the position by the foot of the person that deposits the sets of the plant. The plough follows and splits the drills, throwing a heavy furrow to the right hand over the dung, and in returning along the opposite side throws another furrow of fresh earth over the last mentioned, by which the dung is deeply covered with the loose soil of the ground. A light roll passes along the finished drills and levels the narrow tops, by which a uniform appearance is secured of the young plants, and it ends the planting of potatoes.

Working of the soils.

Potatoes.

In the second week of May, the land intended to be sown with beet-root is raised into drills of twenty-eight inches apart; the half-rotted farm yard dung is spread evenly along the furrows, the drills are split and reversed by the plough, the seeds are inserted by dibble on the tops at the distances of four to six inches, and a light rolling finishes the process. Double drill machines are now fitted with large cups and proper barrels to deposit the seeds of beet-root along the drills, and in both

Beet-root.

ways a rolling of the tops must follow. It excludes drought and retains moisture.

The sowing of Swedish turnips follows the planting of beet-root, and is done in the ways that have been described, the seed being sown along the tops of the drills by a machine of two rows, drawn by a horse and directed by a man. The land to be sown with common turnips in June, receives the last ploughing after the potatoes, and beet-root are planted, being deferred till these operations have been finished. During that month the turnips are sown with farm yard dung, as has been described, and with bones and guano, and other auxiliary manures by the drop drill, which deposits at fixed distances the manure and seed in mixture. The seed is sown over the farm yard dung by the two drill implements. Swedish turnips.

In all these operations of forming and reversing drills with the common plough, the main tree of draught is five feet in length, which stretches over the breadth of two drills, and allows the horses to walk widely, and gives the ploughman a necessary sight of the forward objects. In reversing the drills to cover the dung, the left-hand horse walks in the furrow of the last split drill, and the horse on the right hand travels on the top of the unmoved ridgelet, while the plough splits the intervening drill, and throws a furrow of earth over the dung. By this method, the dung in the drills is not disturbed by the feet of the horses as when the animals walk in the intervals, and the advantage is very useful in not treading on the sets of potatoes which are placed upon the dung. The common plough is more beneficial in making drills than the implement with two mould boards. The narrow-pointed share penetrates deeper and raises more fresh earth than the feathered share of the latter tool, of which the bottom part of the two mould boards constantly heaves the plough upwards, and dispossesses the hold of the ground. Drilling of all green crops.

When lime is applied on the green crop fallows, the pulverized material is spread over the ground before the land is drilled, in the way as described for wheat fallows, or the hot cinders are ploughed into the land, which undergoes one or two subsequent workings in order to mix and disseminate the reduced calcareous substance in the ground. In either way, the lime must come into contact with the soil, when the former is in the hottest state that is possible. Lime used.

Turnip soils are very effectually and economically brought to readiness by the workings of Finlayson's harrow, or a similar grubber. The first ploughing of the land is done in early winter to the depth of seven or eight inches, which affords plenty of loose soil for the future operations of the grubber. The spring working is done across the plough furrow, and repeated in contrary directions till the proper tilth is produced. In the intervals between the operations of the grubber, the weeds and stones are removed by means of the action of the harrow and the roll. The circular tines of the grubber drag the weeds to the surface, and does not expose the land to drought as by the ploughing of the ground. The soil is stirred and pulverized by the repeated action of the imple- Grubber working.

ments, and the moisture is preserved by reason of the land not being turned up. It promises to be a very great improvement in the working of turnip lands.

Art of ploughing

It may not be improper to conclude the notice of cultivation of land with a few observations on the art of ploughing. The first and most important thing to be attended to by the ploughman, is the proper adjustment of the implement by means of the coulter and share. If these parts of the plough be not properly set with a due inclination to the land sideways, and to the earth downwards, the implement will never move sweetly nor easily, it will be ever inclining to one side or the other, go too deep or too light, increase the friction, and distress the animals, and perform the work in a rough and unsightly manner. This nicety of adjustment shows the skill of the ploughman; for, if well managed, the implement should proceed with a very slight touch of the hand. The plough must be held flat on the bottom, and not obliquely, and leave no ridges or rafters, or land unmoved between the furrows. The furrow slices must be all cut of the same width, and be laid at the same height; if laid too flat backwards, or if the furrow itself and not the edge be perpendicular, the harrows cannot raise so much fine mould to cover the seed. The cut made by the coulter in the side of the unploughed land must be as perpendicular as possible, and neat and clean. The reins extending from the bridle of the horse through an iron ring fastened on the leather backband, are held on the rounded extremities of the handles of the plough by means of a plaited groove on the end of the rope, just before the hands of the ploughman; and with well-trained horses a plough properly adjusted, and a tolerably skilful ploughman, the use of the reins will seldom be required, except in turning the horses at the ends of the field. The headlands must not be under twenty feet in width, so as to allow room for the horses to turn without treading on the ploughed ground and leaving footmarks—a most unpardonable blunder in the art of ploughing. The ploughman must walk with both feet in the furrow, and with his body at ease and erect, speak seldom to the horses, and make no blustering noise. Many very good ploughmen walk with one foot in the furrow and the other on the unploughed land, but it rather spoils the appearance, and seems intended to guard against any lateral movement of the implement, which should be wholly prevented by the adjustment. The horses must be trained to walk at a certain distance of space from each other, in order that the ploughman may see clearly forwards to rectify any mistake committed in the preceding furrow. The horses must be yoked to move freely and easily, and as near to the plough as not to impede the freedom of step, with a check rope extending from the inside bridle of each horse to the harness or backband of the other, in order to keep them fairly opposite to each other. It is better when a single connection rope from mouth to mouth is only used; but this mode requires animals of a very uniform temper, and much attention on the part of the ploughman in training the animals to one rate of pace.

described.

Practical directions.

It is a very common opinion that any person may be a ploughman, and

that the performance of the art requires neither pains nor trouble; but experience does not enforce the belief that the operations of any art whatever can be properly performed without attention and trouble. No doubt some processes are easier performed than others, and some persons acquire the mode of performing them easier and more quickly than others; but that aptitude is very far from being a general rule, and forms no exception to the labour and attention that are universally found to be necessary to eminence in any branch of business.

Attention required.

The subject of fallowing lands, either for grain or root crops, must not be dismissed without reminding the cultivator that the proper performance of fallowing constitutes the basis of all good and profitable husbandry; and that if it be neglected, not only the crop immediately sown will suffer, but the damage will extend to all the crops of the rotation. Cultivation means that nothing grows on land except what is sown; and though this degree of eminence may never be attained, as there ever may remain a wide difference between possible and ideal excellence, yet the nearer we approach to it, the nearer we approach to perfection. The constant and vigilant attention of the cultivator must be incessantly exercised to see that all and every part of the operations be duly and strictly performed in the proper season, and to the fullest extent that is required. He must not only give orders that they should be done, but he must see that they are done; and if negligently performed, have the process repeated, till satisfaction itself be satisfied. True economy consists, not in getting things cheaply done, as many persons erroneously suppose, but in getting them well done; and the effects of minute care are very great in increasing the produce of land. The goodwill, activity, and energy of the labourers must be secured and incited by good treatment, which is seldom or never repaid with carelessness or neglect: exceptions do happen, but they are few. The implements must be all of the first order, and kept in full completion, ready when wanted, and never out of repair. The horses must be spirited and active, well fed, and fierce as lions. The very best ploughmen may be wholly lost with starved and useless animals; care is misapplied, and wages are lost in the value. The mind that directs must attract obedience, and not compel submission—lead his fellow-creatures in the most noble of arts, from which he and they reap the same fruits, and experience the same benefits.

Great importance of fallowing,

Rotation of crops, or the order in which the several plants that are used as crops are made to succeed each other, forms a branch of the profession of agriculture, than which no other part requires more judgment, or more conspicuously shows the skill of the farmer; nor is there any portion of the art on which the profits of the cultivator more certainly depend. The effects of plants on the soil are very various; some have a tendency to impoverish it much more than others; some bind and others loosen it: hence it is necessary to attend to the peculiar nature of each plant, and to examine in what manner its culture affects the soil. By this means we shall be enabled to determine in what order we ought to arrange the crops one after another, so as to keep the ground always in

and of rotation of crops.

heart, and yet to make it yield the greatest possible produce, which two particulars form the grand object of a correct and systematic rotation of crops.

Alternation of plants.

Culmiferous crops are such as have a smooth jointed stalk, and mostly contain the seeds in chaffy husks. These, especially when they are approaching the ripe state, draw their nourishment chiefly from the soil, and derive but very little from the air; therefore, when they are cultivated for seed, which is most generally the case, the ground cannot fail to be impoverished by them. On the contrary, the same plants, when young and clothed with verdure, will derive a considerable portion of their nourishment from the atmosphere; and, therefore, a culmiferous crop when cut green, or consumed in that state by animals, does little or no injury to the land. A crop of hay, cut before the seed is ripe, as it should be, does not much rob the ground. Leguminous plants, as beans, peas, and vetches, extract, by means of the broad spreading leaves, most of the nourishment from the air, and none of these plants when cut young injure the ground, but if leguminous plants be allowed to ripen the seed, their effects

Sceded crops.

on the ground are still much less severe than of culmiferous crops in a similar condition. Other remarkable circumstances distinguish those plants. All the seeds of culmiferous plants ripen at the same time. As soon as they begin to form, the plant becomes stationary, the leaves wither, the roots cease to push, and the plant when cut down is blanched and sapless. The seeds of a leguminous plant are formed successively; flowers and fruits appear at the same time in different parts of the plant. This plant is, therefore, continually growing and pushing its roots; hence the value of pea and bean straw over that of wheat or oats; the latter is withered and dry when the crop is cut, the former is green and succulent. The difference, therefore, with respect to the soil, between a culmiferous and leguminous crop is very great; the latter growing till cut down, keeps the ground in constant motion, and leaves it to the plough

Leguminous plants.

in a loose and mellow state; the former ceases growing long before being reaped, and the ground from a want of motion becomes hard and compact. And also dew falling on a culmiferous crop after the ground begins to harden rests on the surface, and is wholly evaporated by the next sun. Dews that fall on a leguminous crop are shaded from the sun by the broad leaves of the plants, and sink at leisure into the ground. Accordingly, the ground after a culmiferous crop is dry and hard; after a leguminous crop it is loose, soft, unctuous, and mellow. Bulbous rooted plants, as turnips, and especially potatoes, are superior to any other in loosening, dividing, and pulverizing the soil: potato roots grow generally eight or ten inches below the surface; and by their number and size they divide and pulverize the ground better than can be done by the plough; and whatever be the natural colour of the soil, it is black when the potato crop is dug up. But carrots and parsnips are superior even to potatoes in this valuable property; for the tap roots penetrate to

Root crops.

a depth of eighteen inches and more, and divide the soil in their course. Turnips are rather inferior as the bulb grows above the ground; but it is still much superior to a culmiferous, or a fibrous

rooted plant. Red clover is similar to the turnip in that respect. From the properties now mentioned which the plants inherit, culmiferous crops in a continued succession would render the soil too hard, and leguminous crops would effect the contrary in making the land too loose; and hence the necessity of making the one succeed the other in alternation, so as to keep the land in a proper state, and at the same time produce the greatest possible quantity of each crop.

In arranging any system of rotations of crops, no invariable rules can be given which will prove adapted to all cases, because very much depends on soil, situation, climate, and other circumstances. In the very variable state of British soil and climate, no very fixed rotations can be prescribed; but there are some material points to be regarded which no circumstances must overlook. The crops must be suited to the nature and state of the lands, and the culmiferous and leguminous crops must be interposed betwixt each other—and this method constitutes what is called the "alternate husbandry;" but it has been found that the lighter soils, are not suited even for alternate husbandry, and that they require a rest in a state of herbage or grass in order to recruit the fertility. Another general rule may be mentioned, that the same kind of crop or plant must not be repeated at too short intervals, or both the produce and the quality will be diminished. And this experience holds as well in green crops as with the cereal plants. Arrangement of crops

The basis of every rotation must be held to be the summer fallows, and the fallows on which the drilled and manured crops are cultivated; and the conclusion of the course to be with the crop taken in the year preceding a return of the fallow on the drilled crops when the rotation ceases, and a new one commences.

In mentioning rotations of crops as a most vital part of the science of agriculture it is by no means intended to convey an impression of the necessity that every farmer should and must bind himself to a slavish routine, but only to direct attention to the study and consideration of that branch of the art from which so many great and lasting benefits have been found to proceed. A cultivator proceeding without a correct knowledge, or some knowledge of rotations, is not unlike a ship at sea without a helm; but even with this knowledge, the real value of every rotation depends, in a very great measure, upon the fidelity shown in executing the several processes of labour that belong to it; though, in the variable climate of Britain, no fixed rotation can be prescribed, yet some rotations must be viewed as more valuable than others, because the crops therein included may be most suitable to the particular soils on which they are cultivated, or the produce may be better adapted to the market demand of the country, which must ultimately regulate the kinds of produce that are most deserving of cultivation. Holding these points in view, alternate husbandry, or the system of having leguminous and culmiferous crops to follow each other, must be reckoned most judicious and deserving of commendation, and with some modifications it may be practised on any soil and in any situation. According to its rules, the cannot be universal: some are general.

land would rarely get into a foul or exhausted state; at least, if foul and exhausted under alternate husbandry, matters would be much worse if any other system was followed. The rotation may be long or short, as is consistent with the richness of the soil on which it is executed and other local circumstances. The crops cultivated may be of any of the varieties that compose the two tribes, according to the nature of the soil and the climate of the district where the rotation is used; and where circumstances render ploughing not so advantageous as pasturage, the land may remain in grass till these circumstances are obviated, care being always taken where it is broken up, to follow alternate husbandry during the time it is under tillage. In this way, it is perfectly practicable to follow the alternate system in every situation—nor is the circumstance of the land being in grass for two, three, or four years, any departure from that system, as it is usually rendered necessary by the scarcity of manure, poverty of the soil, the want or the distance of markets for corn or other accidental circumstances. The basis of every rotation, as before observed, is the bare summer fallow on clay soils, and the fallows on which drilled and manured crops are cultivated; and the conclusion of the rotation is with the crop taken in the year preceding a return of the fallow or green crops, when of course a new rotation commences.

Alternate system.

We now proceed to state the most approved rotations, on strong clays, loams, on the lighter loams, and on sands and peaty soils.

The clay soils which have been found incapable of being reduced in texture to suit the cultivation of green crops, may be divided into two kinds—the superior class, that produces very abundant crops, and constitute the greater part of the arable lands in some districts; while the inferior kinds, which much abound in this kindgdom, yield very scanty and precarious returns. On clays of the best quality, and in situations where manure is plentiful, a very favourite rotation has been: first year, fallow; second year, wheat; third year, clover; fourth year, oats; fifth year, beans drilled and hoed; sixth year, wheat. Manure may be applied on the oat stubble, or in the spring with the beans, if the nature of the land will admit. In the most favoured situations, this rotation is well adapted for alternation, and for keeping the land clean, and in proper tilth. The four years course of 1, fallow; 2, wheat; 3, clover, peas, beans or tares; 4, oats, is much esteemed by many eminent cultivators, and may suit very well on lands of good quality, but the recurrence of the same crop is too frequent on land of any quality, and it is gradually giving way to a more extended rotation. Where the land is loamy, and sufficiently mellow to admit the growth of barley, rotations of six and eight years have been followed, and they include a larger change of plants from that circumstance: 1, fallow; 2, wheat; 3, beans, or peas; 4, barley; 5, clover; 6, wheat or oats: or, 1, fallow; 2, wheat; 3, pease; 4, barley; 5, clover; 6, oats. Here the clover crop is too far removed from the fallowing process, which supposes the land in the best state of preparation for the reception of the small and tender seeds of grasses. A

Rotation on best clay lands:

six years:

eight years.

shorter course is sometimes used: 1, fallow; 2, barley; 3, clover; 4, beans, pease, or tares; 5, wheat: and also: 1, fallow; 2, barley; 3, pease, beans, or tares; 4, wheat: or, 1, fallow; 2, wheat; 3, pease; 4, oats. These courses may be varied alternately with clover in the third year. The longer courses most approved are: 1, fallow; 2, barley; 3, beans; 4, wheat; 5, tares; 6, barley, dunged on the stubbles; 7, clover; 8, beans; 9, wheat: and, 1, fallow; 2, wheat; 3, beans; 4, barley; 5, clover, dunged; 6, oats; 7, beans; 8, wheat. This course may be reduced to six years, by not dunging the clover ley, and by making oats the last crop: and also: 1, fallow; 2, barley; 3, clover; 4, beans, dunged; 5, wheat; 6, tares; 7, wheat; the two wheat crops are here too near to each other, and the fifth crop may very well take the place of the second. Another course has been used as: 1, fallow; 2, wheat; 3, beans; 4, barley; 5, clover, dunged; 6, oats; 7, beans, drilled; 8, wheat. If the land be clean and in tilth for clovers, this rotation claims much merit, and may be improved by exchanging the fourth and second crops for each other.

Barley used.

The following course possesses much merit, and joins the bean and pasturage farming, a circumstance that is never met with, and which would rarely be allowed, by the common ideas of cropping: 1st year, fallow, dunged; 2, barley; 3, clovers; 4, grass; 5, oats; 6, beans, drilled and hoed; 7, wheat. The crops are well varied, and the land derives the advantage of a rest in pasturage, which refreshes the ground more effectually and durably than any manuring. Lime may be applied on the bean stubbles, and the winter ploughing of the fallow will secure a pulverized surface for the barley tilth, if due advantage be taken of a dry state of the land for sowing. The action of the lime might be better developed if applied on the barley or bean tilth, in the spring; but if the climate and soil be precarious, they might prevent the application. A better course can scarcely be devised; but it supposes a loaminess in the clay to admit the growth of barley, which is wholly denied by the viscous marine formations of South Britain. The rotation originated with Mr. Grey, of Dilston, in Northumberland, whose name has been already mentioned in the chapter on "Lease." The land on which it is used is an alluvial clay on the southern bank of Tweed, near Berwick, and consequently a fresh water formation. The idea arose from the very frequent failure of the grass seeds when sown on the stale surface of the winter wheats, and along with the exchange of barley with the wheat on the fallow. Mr. Grey very judiciously combined the grass of two years, a system wherever adopted and perseveringly continued in the due performance, is always attended with the same results of a very superior efficacy.

Very valuable course: from Mr. Grey.

In many places, the land is much too hard and stiff for barley, and then the course of four and five years with beans and oats may be adopted. On inferior soils of this description, the following course may be usefully employed: 1, fallow; 2, wheat; 3, clovers, trefoils, seeds, or cinque

foils; 4, ditto; 5, wheat, or oats, beans, pease, or tares. The grass crops may be prolonged if thought fit, and form a course of six years. Another rotation for inferior clays has been recommended in, 1, fallow; 2, oats; 3, grass; 4, ditto; 5, ditto; 6, beans, drilled; 7, wheat. And also: 1, fallow; 2, barley, wheat, or oats; 3, clovers; 4, ditto; 5, oats. A crop of winter tares sometimes precedes the fallowing process, and are eaten on the ground; but the mode is generally imperfect, as a very effectual part of the process is usually performed by the time the first furrow is given to the land, and the state of cultivation is always much inferior to the fallows that are effected by winter ploughings, which have derived the benefits of atmospheric action. The custom is not unfrequent on turnip soils; but even on these lands, the fallowing tilth will be inferior, except in some few particular cases.

Legumes used.

These courses of cropping suppose lands of good quality, and a capability in the soil of being drilled with leguminous crops, for the purpose of preserving the land in a clean and pulverized condition. But on the inferior clay lands of this kingdom, there is no possibility of drilling any green plants; the dung may be applied on the autumnal stubble, and a leguminous crop may be sown in the spring, but it will be a broad-cast crop, and confers no benefits on the land, and has no tendency to defer the fallowing process. As it has been found impossible to assist the benefits of fallowing to the land by any intermediate operation of dunging and pulverizing the soil, the rotations of cropping on these lands are more curtailed, as the entire processes of the rotation depend on the benefits of fallowing; and the quality of the land will not endure the constancy of cropping that is practised on soils of richer constituent quality. On all wheat lands, the operation of fallowing constitutes the foundation of the whole course: if that be neglected, the future produce will in every case be diminished. If the rotation be formed of alternate cropping, the land is speedily exhausted, and the too frequent recurrence of the operations of ploughing are known to tine lands that are weak in texture and composition. These soils are generally of two kinds,—one of a brick-like nature, and red or black in colour; the other of a much softer texture; and both rest on a wet clay bottom, and more or less retentive, and not unfrequently mixed with sands and gravels. Of all soils they are the most precarious to manage, and yield the smallest returns. They are mostly, but not always, found in inland situations, and distant from the sources of manure, and are unable in themselves to maintain the animals that are necessary to afford the requisite materials of that indispensable article. A farm wholly, or mostly, composed of these sterile clays, is a very heartless concern; but they are generally interspersed with portions of turnip fields, which very much improves the management, on such soils. Wheat has been proved, in most cases to be the most profitable crop, though many high-lying situations will occur where oats may succeed better, from the climate being too late for an early plant. The rotation of four years: 1, fallow; 2, wheat;

Inferior lands.

Sterile clays.

3, grass seeds, mown or pastured; 4, oats, has been, and is yet very injudiciously followed on these lands, for the farmer does not possess manure sufficient to support constant cropping, and consequently a rest in pasturage must be substituted to recruit and refresh the land. It has been proposed to sow pease, beans, and tares during the third year in the field alternately; so that clovers may occur only once in eight years. The following course has been very profitably employed: 1, fallow; 2, wheat; 3, grass seeds, mown or pastured; 4, pasture; 5, pease, beans, or tares; 6, oats. A course of five years may be adopted by sowing any of these plants after pasture, and would become: 1, fallow; 2, wheat, or oats; 3, grass seeds mown or pastured; 4, pease, beans, and tares; 5, oats: or, 1, fallow; 2, wheat, or oats; 3, grass seeds; 4, pasture; 5, oats, or pease, beans, and tares. In high latitudes that are unfavourable to leguminous plants, the following course may be useful: 1, fallow; 2, oats or barley; 3, grass seeds; 4 and 5, pasture; 6, oats. Many or most of the soils are physically inappropriate for barley, and also for leguminous plants; and a failure of the latter crop invariably produces an abundance of weeds, and renders the land very foul. If the tare crop be eaten on the ground by sheep, it would very much assist the following grain crop; but the nature of the land is adverse to such a system, unless in some few cases of soils and of seasons, that are of rare and unfrequent occurrence. Pasture will preserve the land in a cleaner state, and adds to the vegetable freshness, that will supply the place of manure, which the farmer does not possess; and if leguminous crops cannot be obtained in fair quantities, they had better not be attempted, and the poor quality of the soil prevents the use of tares and clovers by being consumed on the ground, for the crops themselves cannot be got in sufficient abundance to confer any benefit on the land by that mode of manuring, the crop of hay being in many instances too light to be cut, and must consequently be used in pasture.

Four years course injudicious.

Legumes and grasses used.

A very general opinion prevails that grasses will not grow on these lands, and certainly for the best of all reasons, because the seeds are never sown. But experience has proved that a close sward may be produced, and sheep grazed and fattened without any danger from rot and other diseases that are so much apprehended on wet lands of that description. The fresh herbage of the sown grasses afford a wholesome bite, which is renewed by a fresh sowing of the seeds, before a contagious deterioration of the herbage takes place. It may not be improper to mention here some plants that have been found to produce the pasturage that is so very desirable on such lands:

List of grass seeds.

Per Acre,

½ bushel of rye grass,	4 lbs. of meadow fescue,
¼ bushel of cocksfoot,	6 lbs. of red clover,
6 lbs. of dogstail,	4 lbs. of white clover.
4 lbs. of catstail,	

If the soil be damp and soft, and does not rank among the hard brick-like clays, the quantity of dogstail may be diminished, and that of the

catstail and the meadow fescue increased. A mixture of rare and expensive grasses would be altogether misapplied on such lands; and in case of soils of any quality, it will be found more profitable to sow a quantity of the seeds that are known to be best suited to answer the purpose, than a mixture of plants that may never grow in any sufficient quantity, and many of which are of doubtful value when obtained. The harder kinds of these soils should be reduced and pulverized, in the early season, by the mechanical action of the plough and the roll, harrowing will be of little use till the later season soften the very adhesive composition of the clay. Lands of any description cannot be too much reduced and pulverized, but they may be rendered too spongy and vacant between the particles, which shows the necessity of consolidation after a complete reduction had been effected. The black and softer kinds will require less labour, as they will crumble spontaneously by the effects of the late rains; and if power was applied to reduce the texture in the early season, the soil would become too fine for wheat, and be apt to throw out the plants during winter. On some lands, the early reduction would be very difficult, if at all possible, but it would be attended with the advantage of consolidating and acquiring a consistency by October for the seed furrow.

For barren clays.

On this latter sort of clay lands, leguminous plants have a better chance of success than on the bricky kinds, and a crop of peas and tares may be very profitably used in the rotation. A variation in the kind of plants that are sown is thus obtained, and a benefit is conferred on the lands by the smothering shade of the leguminous crops; but they ought not to be used unless a crop can be produced to cover the ground closely and evenly, for a thin straggling crop of such plants is the most pernicious to clean lands that is known. The grass seeds should be sown on a surface that is pulverized by harrowing and rolling, and then covered by a lighter application of the same implements.

Legumes barely of use.

Any improvements that may be contemplated to be executed on clay lands, must be preceded by complete draining at the distance of twelve to twenty feet, according to the extreme or partial wetness of the soil; and may be effected by drains running straight, oblique, or across the lands, as may suit the inclination of the locality. Many of the better clay lands are at present in a high state of cultivation in the neighbourhood of towns, and in favorable districts; but the greater part is yet susceptible of very much improvement, and probably of more profitable improvement, than any other kind of land in the kingdom. The draining should be executed as a permanent improvement chiefly by the landowner, with a corresponding assistance from the farmer, or it may be done by the single expense of the farmer, on the proper security of a lengthened tenure. The circumstance of all wet lands not being drained, after the obvious and profitable results which have been obtained by that improvement have been made known to every possessor of the the soil, reflects a disgrace on those concerned, and who have both the means and the power, hardly to be wiped away by the future tardy per-

Draining necessary.

formance. In the midst of the greatest rage and outward anxiety for improvements, the most obvious, the most necessary, and the most certain of any in the result, is much neglected, and without which operations in that class of soils, all other improvements are in a great measure lost in effect. The cutting and clearing the courses of brooks and rivulets must precede or accompany draining, and also the opening of the receiving ditches round the field; and, after the complete drainage has been effected, the modern improvement of ploughing the subsoil may be introduced, and followed by an application of calcareous earths, limes, and chalks, in quantities of 300 to 600 bushels an acre, in order permanently to alter and improve the texture as the nature of it may require. Any general benefit that might be derived from the use of calcareous matters on such soils is lost by reason of the want of quantity, and from the land not being prepared for the mixture. It remains to be seen what ultimate effect the complete drainage will operate on these stubborn clays, if they will be converted in any instance into a fit state for green crops, or only rendered more accessible at the different seasons, and easier of management by the present mode of cultivation, in addition to the increased productiveness. Some soils, from an original near alliance, may be rendered fit for green crops, but the most truly clay lands are probably placed beyond that possibility. When such improvements are required to be performed, they should be done at once, promptly and effectually, for not only is more time gained for reaping the benefits, but the frittering policy is avoided which squanders the means of action on many points, and effects no object completely, and by which the produce of each is lessened from want of concentration to produce any satisfactory results. In no active business of life has this policy, absurd and puerile as it must appear, been attended with more mischievous consequences than in agriculture, for with some very few meritorious exceptions, it pervades every arrangement and detail of operations, and fetters and prohibits any very great advances in the improvement of the art. When a quantity of means is allowed to effect any object, it is very usually exerted on multiplied points of resistance, and none of which is overcome by reason of the force being too small that is applied to each, and consequently none of the objects are productive of the expected results.

General clearance of water-courses.

All necessary for the action of cultivation.

The general mode of reducing and working clay lands by exposure during the heats of summer and the vicissitudes of the weather is well known, and, in most cases, is performed in tolerable perfection; but observation has shown that the covering of land produces a fertilizing effect, and kills weeds; and it is probable that, at some future time, there may proceed from this hint an important and valuable alteration in practice, which may be ascertained by a few decisive trials made on fair and tangible grounds, which do not in the smallest degree affect the usual results of cultivation, and at the same time are fitted to justify the conclusion. The covering that would be afforded by a crop of tares, or a similar substance, to rot on the ground, might lead to some means of

Covering of land.

accomplishing the purpose. Straw has been applied one inch thick as a covering to wheat seeds pressed into the soil on untilled lands, and the crop yielded a very large return of sound and healthy grain. The straw would afford protection against both cold and drought, and also nutritious matters by its decomposition, and the weeds will be effectually destroyed. One good crop of any plant may be got from a single process, and yet be inadmissible into a system; the means that are required for the purpose of protection must be carefully considered, and also the bearings on the future crops, and also on the other parts of the prevailing mode of cultivation, as it may operate more damage in some quarters than the advantages that are derived in another. Such suggestions tend to confirm the seemingly very just opinion that all manures are best applied on the surface, and that plants derive the chief part of their nourishment from the atmosphere, and that the earth performs only a secondary part in the process of vegetation. Dung covered in the soil encourages an exuberance of roots and fibres, whereas all healthy and soundly productive plants have the roots sharp, hard, and crisp, like the claws of a bird. Wheat covered with straw on a plate of glass grew well, which further confirms the theory. The present modes of production are very laborious and expensive, and our investigations may probably soon discover much easier and shorter roads, for in the progress of observation and of science, the necessity is daily felt of surrendering opinions and maxims which have long been trusted and received on authority; and we must not suppose that our observation and experience have explored all the paths, or exhausted all the stores of nature.

May be of future use.

The grasses may be given which are suitable to be sown, with the different rotations of cropping.

Grasses for cropping.

For a hay crop of one year,
Sow per acre,

½ bushel of ray grass,	4 lbs. of catstail,
¼ bushel of cocksfoot,	10 lbs. of red clover.
4 lbs. of meadow fescue,	

For hay of one crop and one year in pasture,
Sow per acre,

8 lbs. of red clover,	¼ bushel of cocksfoot,
4 lbs. of white clover,	4 lbs. of meadow fescue,
½ bushel of ray grass,	4 lbs. of catstail.

The grass plants have been already mentioned that are proper to dry arid clays in permanent pasture of two and three years.

On the subject of clay lands, and the proper rotations, the reader is referred to "*Clay Lands and Loamy Soils*," price 1*s*., published by Weale, and written by the author of this work. In that treatise, the various kinds of clay are investigated and described, geologically, chemically, naturally, and practically, in a very systematic and detailed order; the proper cultivation of each kind of land is stated from the best experience; the rotations of cropping that are suitable to each soil, and

the grasses adapted to the nature of the grounds. The comprehensiveness of the little work very much enhances the value.

Turnip land rotations.

The second class of soils that was mentioned contains the better turnip lands and the loamy clays, that are capable of being cultivated and planted with green crops. These soils constitute the most valuable class, and are capable of producing in abundance all the plants that are held in the highest estimation for the purposes of husbandry. The fallowing crops are: swedish turnips, potatoes, and mangel-wurzel, being the most valuable plants that are known, and all of them capable of being raised on these lands with due preparation and encouragement. On many loamy clays, draining will be required, and must be performed, before any other expense be incurred. These crops can be removed to admit wheat being sown at the proper season, and hence the high value of the land in producing the two crops of the greatest value in succession. A course of six years is much approved on these soils: 1, green crops; 2, wheat; 3, clover cut for hay, or used for soiling, or consumed by live stock on the ground; 4, oats or leguminous plants; 5, winter tares or late turnips consumed on the ground; 6, wheat. On the four years' course: 1, green crops; 2, wheat; 3, clover; 4, oats. Beans, horse and hand hoed, may be used along with the winter tares, in portions and alternately, as the rotation goes on, and the land will then obtain a change of plants, and the green crops may be varied to suit a similar mode of cultivation. The four years' course: 1, turnips; 2, barley; 3, clover; 4, wheat is too short, and the same plants recur too frequently; and it has been proposed to double the course, and to extend it to eight years, thus: 5, cabbages or mangel-wurzel; 6, oats; 7, tares or pease; 8, barley: and, for two years more, 9, beans; 10, wheat: and also, 1, turnips or cabbages; 2, barley; 3, clover or tares; 4, wheat; 5, potatoes or beet; 6, barley; 7, clover; 8, oats or wheat: and also, 1, beet or potatoes; 2, oats; 3, clover; 4, wheat; 5, turnips and cabbages; 6, barley; 7, beans, pease, and tares; 8, wheat. The rotation of eight or more years is a repetition of that of four years, with the object of changing the plants raised as green crops, and substituting a leguminous and clover crop alternately, so that each occurs only once in the course of the rotation. But this object may be attained by varying the four years' course in the fields, as they occur for cropping in succession; and if the soil be not all alike suitable for similar cropping, a change in the plants will be necessary. A course of five or six years is most generally to be preferred, and is found the most commodious, as it affords a full opportunity of cultivating the most valuable plants, and also of profitable alternation.

Best soils.

A course of six years has been very usefully employed—1, turnips and other esculents; 2, wheat; 3, beans, pease, or tares; 4, barley; 5, clover; 6, oats; unless the land is very clean and in high condition, the clover crop is too far removed from the clearing and manuring process, otherwise the crops are well arranged. It is desirable that one crop is

Legumes used.

eaten on the ground, as an auxiliary manure to support constant cropping as a leguminous crop is proposed in a similar course on clay fallows, and then the rotation would stand thus: 1, green crops; 2, barley or wheat; 3, clover; 4, oats; 5, vetches consumed on the ground; 6, wheat: and in five years thus: 1, turnips; 2, barley; 3, seeds; 4, pease, or tares consumed in the ground; 5, wheat or oats. Good lands, when well cultivated, will produce two crops of wheat in six years, and will not require the fallow manuring oftener than once, as it will have the benefit of a crop consumed on the ground. In some cases of very favourable situations, the auxiliary manuring may be withdrawn; and if the fallowing for green crops occurs twice in six years, it is evident that the rotation ceases. It is more pleasing to see a field under a crop of one plant, than of many kinds—and if a farm be suitably divided, alternation may be accomplished without much subdivision in that respect.

Inferior lands.

These rotations apply to clayey loams of the very first quality. On those of an inferior description, and on the best turnip lands, rotations somewhat different are used, including grass for two years, where there are no grass or meadow lands for producing hay and pasturage for the live stock. A course of six years includes the following crops: 1, turnips, or other green plants; 2, barley or wheat; 3, clover; 4, grass; 5, beans, pease, or tares; 6, wheat or oats alternately on the fields. A course of five years is followed by omitting the pease and beans, and sowing oats as the fifth crop—or pease and beans may be sown in the fourth year, and followed by oats. A course of eight years has been recommended: 1, turnips; 2, wheat or barley; 3, clover; 4 and 5, pasture; 6, oats; 7, tares; 8, wheat: or it may be limited to seven years' by omitting one year of the pasture. These courses of cropping are adapted to loamy lands, and it may be very safely affirmed, that no better are yet known.

Grass seeds.

The proper grasses are, for hay for one year,

Sow per acre,

¾ bushel of ray grass,	6 lbs of catstail,
¼ bushel of cocksfoot,	12 lbs of red clover.
6 lbs. of meadow fescue,	

For two years' grass,

Sow per acre,

12 lbs of red clover,	½ bushel of cocksfoot,
8 lbs of white clover,	6 lbs. of meadow fescue,
½ bushel of ray grass,	6 lbs. of catstail.

These soils produce large crops of hay, with a luxuriant pasturage, and should be very liberally seeded.

Lightest lands.

The third division of soils that was mentioned, consists of inferior loams, sands, chalks, and gravels. These lands are chiefly adapted for green crops, and for sheep feeding, and the quality in many instances not permitting the production of an average weight of the heavier roots, herbaceous and leguminous plants have been employed, which yield a maintenance for sheep, and consequently a manuring to the

land. On the inferior turnip lands, the following rotations have, for a long time, constituted a very successful practice: 1, turnips; 2, barley; 3 clover; 4, pasture; 5, oats; and on the lighter qualities of land: 5, pasture; 6, oats and pease and tares may be sown on the grass turf, to supply the demands of the farm. The great advantages that are here derived, consist in the vegetable remains that are accumulated for decomposition, and it has been found that land cultivated in this manner, yields greater returns both in grain and in animals, than when used in constant cropping of more than a usual proportion of the ameliorating crops, and supplied with all the manures that the crop afforded.

For hay and 2 or 3 years in pasture,
Sow per acre on sands and gravels,

8 lbs. of red clover,	6 lbs. of crested dogstail,
4 lbs of white clover,	2 lbs of barley-like fescue,
½ bushel of ray grass,	2 lbs. of yellow oat grass,
¼ bushel of cocksfoot,	2 lb. of upright brome grass.
2 lbs. of hard fescue,	

On inferior loams,
Sow per acre,

½ bushel of ray grass,	4 lbs. of crested dogstail,
¼ bushel of cocksfoot,	4 lbs. of hard fescue,
8 lbs. of red clover,	4 lbs. of meadow catstail,
4 lbs. of white clover,	2 lbs. of yellow clover,
4 lbs. of meadow fescue,	2 lbs of rib grass.

The land acquires a freshness and a consolidation from the rest it enjoys under pasture—but it supposes a dampness in the soil and climate to induce and favour the growth of grass seeds that are sown for pasture. In many cases of the very hot and dry soils in South Britain, it is wholly impossible, to procure by any means, a sward of grass—and hence the necessity of using the green crops for sheep feeding, and of sowing very few grain crops, and in a very diminished proportion. On hot burning sands of the iron description, and on some chalks and gravels, a grain crop very seldom succeeds; if the early months of the year be dry and hot, a total failure very often ensues, where autumn sown rye would yield a much greater produce both from its nature, and from attaining a tall growth, and forming a shade to the land before the scorching heats commence. The most inferior sorts of these lands will be most profitably cultivated by a succession of three or four feeding crops to one of grain for seed: rye, winter tares, and summer sown rape, may be succeeded alternately by turnips, rape, and spring vetches, and relieved occasionally by a crop of clover and corn. On chalks, gravels and sands of the better quality, a course may be adopted thus: 1, turnips; 2, barley; 3, winter tares, consumed on the ground; 4, rape, also eaten on the ground; 5, spring vetches, also consumed on the ground; 6, rye for a seed crop, being four feeding crops to two of grain: or, 1, turnips; 2, spring vetches; 3, rye for a seed crop; 4, winter tares; 5, rape; 6, barley—each grain

Scorching soils.

Rotations.

crop having thus the benefit of two crops eaten on the ground. A crop of clover sown at the rate of 30 lbs. an acre, may succeed the barley crop, and may be cut or consumed on the ground as may be required. The very inferior soils and burning sands may be well used in a similar manner, with one crop of seed rye to four of the feeding plants—as, 1, turnips; 2, barley or oats; 3, clover; 4, tares; 5, cole. Thus rye, winter vetches, turnips, spring vetches, and rye for feed, may be followed at pleasure by turnips, barley, and clovers—and the lands may be then successively cropped with those plants, and kept in good condition.

Peaty soils. Peaty soils and lands that have been pared and burned may be cropped in a similar manner, according to quality, and always with a large and full proportion of the feeding plants. On clayey soils, pared and burned: 1, turnips or cole; 2, oats or wheat; 3, grasses or tares; 4, pease or beans; 5, oats; 6, fallow, followed by wheat and grasses for several years. On thin clays: 1, cole; 2, oats; 3, pease, beans, and tares, oats or wheat, followed by cole, oats, and grasses, for several years. On chalks, sands, and peats: 1, turnips or cole; 2, barley or oats; 3, grasses; 4, grasses; 5, grasses; 6, oats; 7, tares or pease; 8, turnips; followed by barley and grasses for a time: or, 1, turnips; 2, barley; 3, grasses or trefoils; 4, ditto; 5, pease; 6, rye; 7, turnips, followed by barley and grasses.

For a more detailed, and separately arranged enumeration of the rotations of crops, on loamy soils, the reader is referred to "*Clay Lands and Loamy Soils*," price 1*s*., published by Weale, and written by the author of this work. The various kinds and modifications of loams, are very fully described, and the use and improvement specified and suggested.

The division of the different soils as above-mentioned, will comprehend every possible variety—and it is presumed that the above rotations will be applicable in most cases, with the variations that particular circumstances and opinions are known to require.

Experience of rotations. Experience has now fully established the fact, that in a proper rotation of crops, a plant with a naked stem, and a farinaceous seed should follow one with a branched stem and a fleshy root, which has been taken from the ground without bearing seed—and if all these conditions cannot be obtained, that some one of them, at least, must be complied with. Wheat sown after clover, which is allowed to be the best succession on light soils, fulfils all these conditions when it is sown after beans, the condition of the preceding crop not ripening the seed is given up, and consequently this succession is inferior to the other. It is not possible, however judiciously the land may be manured, to raise the same crops in regular succession, without loss and detriment both to the land and in the quantity of the crops. Wheat and clovers answer well in alternation, but not singly; and this shows that the same effect is not produced in the soil by these two crops. Experiments have been made by very eminent chemists, particularly by Macaire of Geneva, at the request of Decandolle, the celebrated botanist, which lead us to suppose, that in the formation of the seed, or other nutritious parts of plants,

the sap is digested, and that it takes up certain elements and deposits others, which are the residue of the process—and these being no longer necessary for the formation of the seed, are rejected by the vital action of the plant, and exude by the roots. Thus certain inferior animals, which in many respects have some analogy with the vegetables in their growth, as the "polypes," take in nourishment by the same openings or pores by which the excrements are voided after digestion; and the different constitutions of different animals enables one class to feed on the excrements of another—whereas, no animal in a healthy state, can derive nourishment from that which has already been digested and voided. Our ignorance of the functions of vegetable life prevents us from seeing the effects produced on the sap, by the expansion of the blossom, or the ripening of the seed; but experience leads us to perceive, that certain plants thrive best after certain others—and that in this case, they are always of distinct and different natures, and of different natural botanic families. Macaire, and some other scientific men, observed the change that took place in the water, in which wheat had been made to grow. They found a deposit in the water of the nature of bitter extract, and this they considered to be excrementitious. Beans grew well in this water; and on the other hand, wheat throve in the water in which beans had grown. The effect of fallowing land is explained on the same principle—the excrement is washed out by the rains, or it is decomposed by the light and air to which it is exposed by repeated ploughings: thus the land is "sweetened,"—an expression very common among the farmers engaged in fallowing. However interesting it may be to the curious enquirer, to ascertain the real causes, it is sufficient for the practical farmer to learn by experience, what crops do succeed best after each other, and how soon the same kind of seed may be sown again in the same ground, with a reasonable prospect of its producing a good crop—and this, after all, can only be learned from actual experiment and observation.

Exudation of plants.

Not fully recognised.

Experience the best guide.

CHAPTER IV.

BUILDINGS NECESSARY ON CULTIVATED LANDS,—DWELLING HOUSES, FARMERIES, AND COTTAGES FOR LABOURERS.

The farmer of land having obtained a security for the outlay of his capital in a lease of the proper duration, and being provided with a sufficient quantity of the means for the necessary operations of cultivation, the attention is next directed to the provisions of the fixed appendages of the farm, on which his capital is to be used, and his occupation has to be employed. The tenant uses a number and variety of tools

Farm buildings.

in the cultivation of the soil, some of which are possessed of life, and others are inanimate, while many are fragile and evanescent, and require a frequent renovation. All these articles, of whatever denomination, demand a provision for their use, and done in such a way as will lead to the utmost fruition of the development. And the first implement to be considered is the farmer himself.

Dwelling house.

The increasing opulence, and gradual refinement of the age, demand a provision of personal comforts, which are suited to the station in society that is held by the individual representative. The accommodation of the "Farm House" must be suited to the value of the farm, and the habits and condition of the occupier. The opulent and extensive farmer will require a very different kind of house from the humble tenant of a small farm. He will expect personal conveniences suited to his condition; and a man of good capital, accustomed to the conveniences of society, will hardly consent to hire a farm which does not possess them, The uniform progress of things leads to this natural condition, and the state of the dwelling houses in any country is a very sure indication of an improving, a stationary, or a non-progressive tenantry. The tenant who is little superior to the condition of a labourer, will be satisfied with a comparatively humble dwelling, and his physical comforts would not be any way increased by furnishing him with a house superior to his habits and ideas. Hence the dwelling houses of farmers are to be varied, and uniformity is as little admissible in that department of social life, as in any other branch of occupational business.

Assuming the medium size of farms at 300 acres, the possessor of that extent must have a capital of £2000 to £3000, and the deriveable annuity from this sum entitles the receiver to a genteel and comfortable residence.

Its accommodation.

The accommodation of the house must be respectable, and afford the proper conveniences to the tenant and his family. In the present social ideas, a division is required between the master and his servants; and the sitting and sleeping apartments of both grades must be separated. This arrangement requires the dwelling house to be two stories in height, and the ground floor to consist of apartments in which the inmates are separated in employments, and in the places of abode. The master's family requires a sitting room, in which to live promiscuously, and where the sittings and the conversations are done—and another room for the purpose of assembling at meals, and which is kept for that sole use. The farmer will need a room for his business of accounts, and for the visits of his employés—another room is very useful as a nursery for the children; and where no family is, it may be used as a spare or lumber room. The accommodation may extend to five rooms, and must not be under four, in order to meet the extent of capital employed, and which demands some comfort for its use. There must be a kitchen of suitable dimensions, and a scullery or back kitchen adjoining, and also a pantry and dairy. These apartments are most conveniently placed in the back part of the dwelling house, and to open into the area behind, which contains the fuel and the ashes, and other minor conveniences. The second floor is di-

Apartments.

vided into four or more bed rooms and closets, which will accommodate the family of the farmer, and the occasional visits of a stranger. The sleeping apartments of the servants are reached by a different stair from that by which the family ascend.

General description.

Our limited purpose does not allow a very large advance into the subject of farm buildings—a general description and exhibition can only be given; but at the end of this chapter, references will be given to special publications on the subject, which contain a large variety for selection, and an utility that ever must accompany all such devices. Two designs are here given of dwelling houses, which will show the intent of our purpose, and point to the accommodation that is thought to be required.



A Sitting Room.	D Scullery.	G Yard.	J Wash-house.	M Closet.
B Best Room.	E Lumber.	H Fuel.	K Privy.	N Stairs.
C Kitchen.	F Ashes.	I Dog.	L Dairy.	O Bed Rooms.

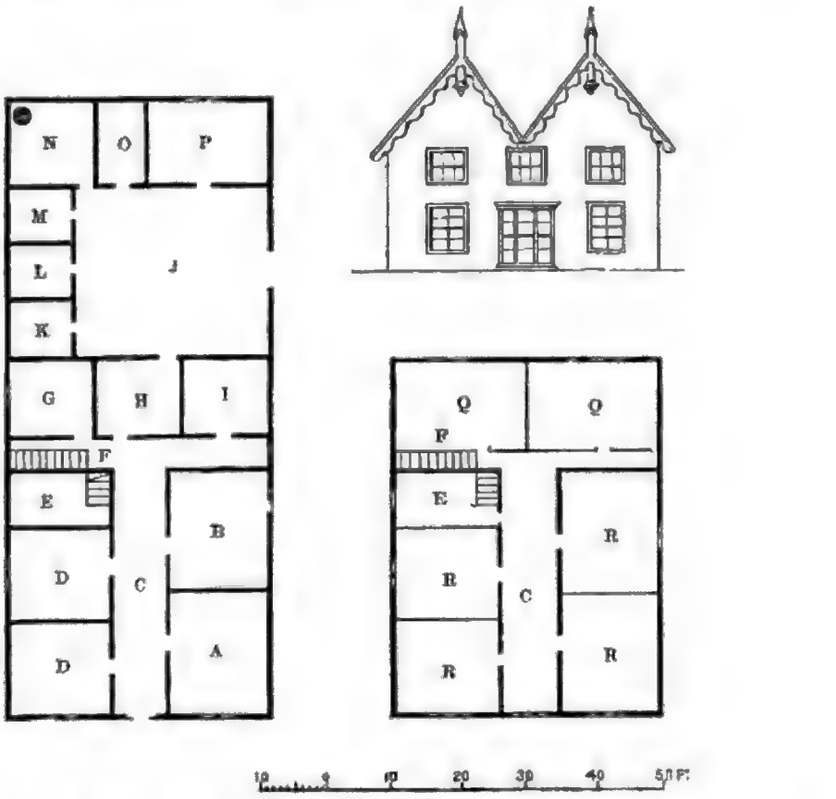
Plan, No. 1, contains two rooms in the length, and is entered by a central front door, and by turning to the right and left. The fire-places are in the gables, and each room has a window in the front. The lobby leads to the back apartments, and from it the stair springs to the second floor. The second floor is divided into three bed rooms and a closet, for the family of the farmer, and a sleeping apartment for the female domestics. The rooms are all specially marked in the plan.

Extra buildings.

It is absolutely essential to every habitation of civilized nature, that there be some back buildings for the performance of dirty operations, and for keeping articles out of sight that never should be seen. The position of these accommodations is best right behind the dwelling houses, in the length of the dwelling, and joining it at the ends. The dairy occupies the east side, as being a cool exposure; and there are placed in the small square, as seen in the plan, a wash-house, lumber room, a house for fuel, ashes, and a privy, and an apartment for a dog. These erections are low, and stand as lean-tos on a wall that surrounds the enclosed area.

This house is suited for farms of 200, and to 300 acres, and presents a

very snug accommodation. The garden may be in front, or on the west side, as will be afterwards discussed, when mention is made of the general position of farm buildings in the useful connection.



A Sitting Room.	E Stair Closet.	I Kitchen.	M Privy.	Q Servants' Rooms.
B Parlour.	F Stairs.	J Yard.	N Wash-house.	R Bed Rooms.
C Passage.	G Larder.	K Fuel.	O Lumber.	
D Rooms.	H Scullery.	L Dog.	P Dairy.	

House end for front.

Plan, No. 2, is calculated for extents of land in 300 and 400 acres. The end of the house stands for the front, which is entered by a porch. The house is of double width, and contains two longitudinal ranges of apartments. which are covered by two tiers of roofing, that meet in a central valley, along which the water flows to the back end of the dwelling. The central passage of the house leads to the kitchens, which stand across the dwelling, and have a side door opening into the back area, of small accommodations, as in the last design. The sleeping apartments are arranged and divided for the family and the servants, according to the ideas already expressed, and the former plan.

Materials.

The houses are built with mortar, stones or bricks, as the materials may abound in the locality. The rooms are floored with deal, and the kitchens are paved with flags or flooring bricks. The side walls and ceilings are plastered in the usual way, and in the better rooms are covered with paper. The second floor is joisted and laid with deal in the common method of finishing such work. The roofs are covered with tiles or slates, as the locality may direct.

A good sized garden for growing fruits and vegetables is a most useful, and, in fact, a most essential appendage to any extent of land that is intended to be let for cultivation. It must be made into shape, and very amply provided with fruit trees and shrubs, by the expense of the proprietor; and when suitably accommodated, it constitutes

a very great inducement to the occupation of the farm by wealth and respectability: when joined with a commodious and neatly furnished dwelling house, a very large portion has been accomplished in these two appendages, of the fixed provisions which constitute the necessary furniture of a farm. The farmer himself must be first accommodated, and then will look to the maintenance, in comfort and safety, of the live and dead stock of his employment. The landowner sadly neglects his own interest, who omits the above-mentioned provisions, on a scale that is rather above than below the standard which the occupation may seem to require.

Farmeries.

Farmeries constitute the mass of houses which are grouped together for the special purposes of the tenant of land, and are a very important part of the fixed provisions of the farm. The houses are designed to enable the farmer to thrash, prepare for use, and lay in store, the produce of the ground—to lodge and feed the horses, and other labouring cattle, and to separate, shelter, and fatten the oxen, and other live stock; to preserve the implements and machines; to collect manures; and generally to carry on the works that are required to be performed under the shelter of roofs and buildings. The principal parts of the farm houses are the barns, the stables, the feeding houses, the yards or courts, and the shed for containing the implements and machines of the farm. The barn consists in a ground floor, on which the thrashed grain falls from the upper floor, where the machinery is at work, and where it is dressed by fanners and made ready for use. The straw is thrown by the machinery into an adjoining house, called the straw barn, in which the straw is lodged, and whence it is carried as wanted for the different purposes of use. These buildings are required to be two stories high, to lodge the thrashing machinery on a second floor, and to afford room in the straw barn, for the accumulation upwards of the thrashed culmy materials. A central position must be given to the barns, as a very frequent access is required. The shed for implements demands a northern exposure, in order to preserve the tools from the heats of the sun, and being vacant below on the ground floor, it affords the best store room over it for the lodging of thrashed grain. Two stories in height afford a shed, and a granary over it; and the building most conveniently adjoins the thrashing barn, in which an inside stair leads to the granary floor. A house for holding small tools, under lock and key, adjoins the cart shed, and is floored over with it.

Description.

Sheds and

The stables are contrived to lodge the work horses of the farm; and the house may be only of one story in height, but open to the top of the roof, and no floor over it. Each animal stands in a trevise of six feet in width, and is provided with a rack in front, and a manger by which to be fed with hay and grains. The width of a stable within walls may be eighteen feet, and the ventilators placed at the ridge of the roof. A hay house adjoins the stable, and in it the corn chest is placed, into which the grain descends by a spout from the granary above. Young horses are kept in yards during winter, and are introduced to the stable as they are broken to work. The riding stable is fitted for, at least, three horses, in the same way as the working stable.

Stables.

Cow shed. The cows, which breed the fattened animals of beef demand a very suitable accommodation; and as some part of the milk will be required for domestic purposes, the position of the cow shed is most commodious on the west side of the farmery, where it will be near to the dwelling of the farmer. The animals enter most conveniently by an end door, and stand in double trevises of two together, and are tied by chains round the neck. The house for lodging the calves adjoins the cow shed, where the young animals are confined in single pens of about ten by four feet, divided by wooden partitions, and on a boarded floor, thickly pierced with auger holes, in order to convey the moisture into the vacuum underneath. If suckled, the calves are led by halter to the cows: if fed by pail, the door of each apartment is provided with an opening in the centre, through which the calf puts its head, and drinks the milk. These houses, the riding stable, hay house, and gig house, are one story in height, and form the west wing of the farmery, which adjoins the dwelling of the farmer, and are convenient to the special purposes.

Feeding Yards. Experience not having yet decided the single superiority of the two modes of fattening cattle, tied in stalls, and loose in yards, both ways may be adopted; and accordingly a feeding house is placed in the farmery, in which any backward animals may be forwarded, and any choice beasts placed for the first selection. The animals stand in double trevises, and are supplied with roots and hay from houses that adjoin each end of the feeding apartment. The yards are divided into large and small extents for young cattle and feeding beasts. Each yard has a shelter shed, in which the animals repose from colds and heats.

Swine and poultry are so wholly distinct from horses and cattle, that they are much best kept in separate apartments, of which designs and explanations will be given.

Liquid draining. The liquid excrements of the farmery are most beneficially absorbed by the straws and litter of the yards; but if the quantity of these articles be deficient for that purpose, oozings may be led and conducted to a central point, in front of the farmery, and fall through an iron grate into a covered drain, which conveys the urine to a tank, in which a mixture is made with earths and vegetable matters. But on farms that are systematically arranged and conducted, the straws will be in abundance to absorb the urinary feces of the proper quantity of animals. In very rainy countries, the rain water from the roofs of the houses is intercepted by spouts at the eaves, and conducted from deluging the yards with moisture. Water is supplied to every part of the farmery, by conducting water from higher ground to an elevated cistern, where pipes lead it to troughs, and supply it to them by means of ball cocks: or a force-pump raises water to the cistern, which supplies it as above.

Remarks. All enlightened practical men have agreed for a long time past in the opinion, that there is not a wider field to be seen at present in any branch of rural economy, than appears in the arrangement and construction of farm buildings. Very great and beneficial alterations have certainly been made within the last half century, and which are in some degree corresponding with the extensive improvements in other bran-

ches of the rural art; but in many parts of the kingdom, it may be said that any advances on that point have not yet commenced; and even where a considerable progress has been made, or at least attempted, a suitable effect has not been produced, from want of the necessary knowledge and judgment in adapting the extent of the accommodation to the purposes required, and in combining and adjusting the utility of the whole concern with the proper expenditure. From looking at the present state of farm buildings over a great part of the United Kingdom, it would appear that ingenuity had been employed to devise and erect the most awkward and useless forms imaginable. Declivities are chosen for the sites of farmeries in order, it is said, to keep the yards dry, and, at the same time, to discharge the whole quantity of moisture into ponds and ditches, or into the ruts of a public road; the straw lies dry and unreduced, and becomes very unfit for the purposes of manure. The houses are scattered and disjoined, and require a useless quantity of fencing to connect them—the yards are large, open, and exposed, and afford a very insufficient accommodation and shelter to the animals, and no proper means of preparing manure in the most approved and economical manner. The useless expenditure in building large timber barns has been long condemned by every practice of enlightened knowledge—being an expense fully double of what is required to be used on that point alone. The same latent barbarisms of the mind that retard improvements on other points operate with full force in this respect—an aversion to make the necessary outlay, and a general and very strong inclination to continue the old usages and erections at the least possible expense, and to repair and patch up so long as any possibility exists, and the want of security in the case of any person, except the landowner, expending capital even for such a necessary and essential purpose. An improper expenditure, might, no doubt, be incurred, by making a number of extensive alterations at one time; but by gradually introducing the best plans, as occasion may require, and opportunity offers, either piece-meal or altogether, an important and valuable change would soon be made, which would show a very different result from the frittering policy generally pursued, of expending money on many points, which only serve a temporary purpose, and which, if combined, and directed to one or more chief objects would introduce some positive benefit in one place, and then in others, as it may be successively applied.

Bad arrangement.

Continued in use.

In consequence of the general aversion to make the necessary outlay, and the adoption of a temporary system of management, few opportunities occur of showing a suitable and economical erection of buildings on any farm; but few farmers will refuse, and offers are made to pay the usual interest on the cost of an improved farmery for the lease of twenty years; and such an erection will always be an inducement to pay a higher rent, and will become itself a capital in money, paying the usual revenue of profit. A certain class of cultivators will deny that any improvements can be made—and another class, more irrational still, will acknowledge that the suggested improvements are all very good, but that they are not required, and are unnecessary—reasons that cannot for a moment be admitted by any intelligent mind. In many places, where large

New designs necessary.

Proper expenditure.

sums of money have been expended in erecting farm buildings, very glaring blunders have been committed, and much ignorance has been displayed, even of the most simple and evident details of practice, arising from the incompetency and conceit of the persons employed who have never practised the art they pretend to assist, and therefore do not know the wants they attempt to supply. The land-owner very generally makes an unprofitable expenditure upon unnecessary erections, and in useless decorations; or is led away by the plans of architects, who, however well qualified to plan and build dwelling houses, gothic windows, and spiral columns, experience has shown to be most miserably deficient in contriving and placing the accommodations that are required on a quantity of land in cultivation. The economy of labour that is derived from the juxtaposition of articles that are required to act or to be used in combination, has been wholly disregarded, if the advantages were fully known—barns and rick-yards have been placed at opposite sides of a large farmery—stables and cart sheds in a similar manner, and the granary placed at a distance from the barn, for the evident purpose of creating useless labour in carrying the grain from one place to the other. Farm horses are often allowed to enter through a cattle yard, and, in many cases, must travel round the farmery in order to reach the cart shed. Pigs are huddled into some cold damp corner, and the poultry are similarly treated, and the door of the house is often found opening to the north, which is the coldest exposure of any quarter of the heavens. These two kinds of live stock require much warmth, and a sunny exposure, and their common treatment is just the reverse. Many similar blunders might be pointed out which must be obvious to any experienced person, and which abound in the best publications on the subject. However simple the matter may appear, no person is capable of devising plans of convenient farmeries, without the most intimate knowledge, from long and extensive experience, of the most minute details of practice; and the first requisite is to ascertain the number and size of buildings that may be required on any lands under a certain system of cultivation, without too much curtailment to create inconvenience, and without any useless appendages that require an unnecessary expense—and then how to connect them, so as to afford the greatest possible convenience with the least possible labour.

Judgment required.

Experience necessary.

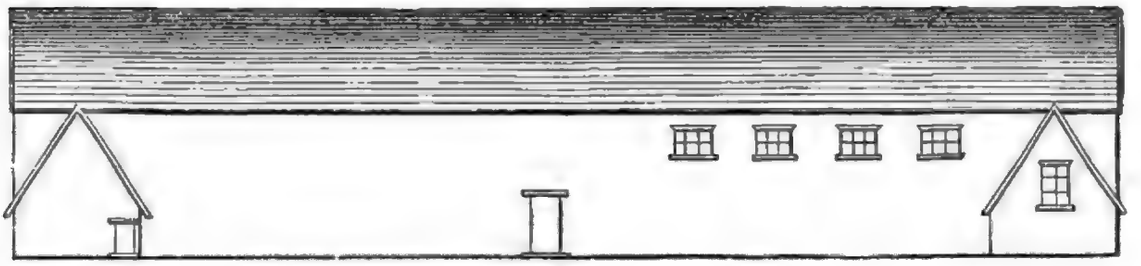
In planning farmeries, two mistakes are very apt to be committed—to extend the buildings too much, and make the yards cold and uncomfortable; or to make them too confined, and consequently deficient in ventilation and fresh air. It is no easy matter to steer midway of the two extremes: situation and exposure will claim much of the direction of the arrangement, which local experience only can know and estimate. Hence arises in a very great degree, the frequent occurrence of a wrong exposure and of insufficient accommodation—of one thing very good, and another very bad, placed side by side—all showing the paucity of ideas on the subject, and the niggardliness of execution. With the present accommodation, as it is most generally found, the farmer cannot use the winter crops so as to derive the full value: he is consequently discouraged, and has not the proper inducement to expend his capital on the legitimate object,

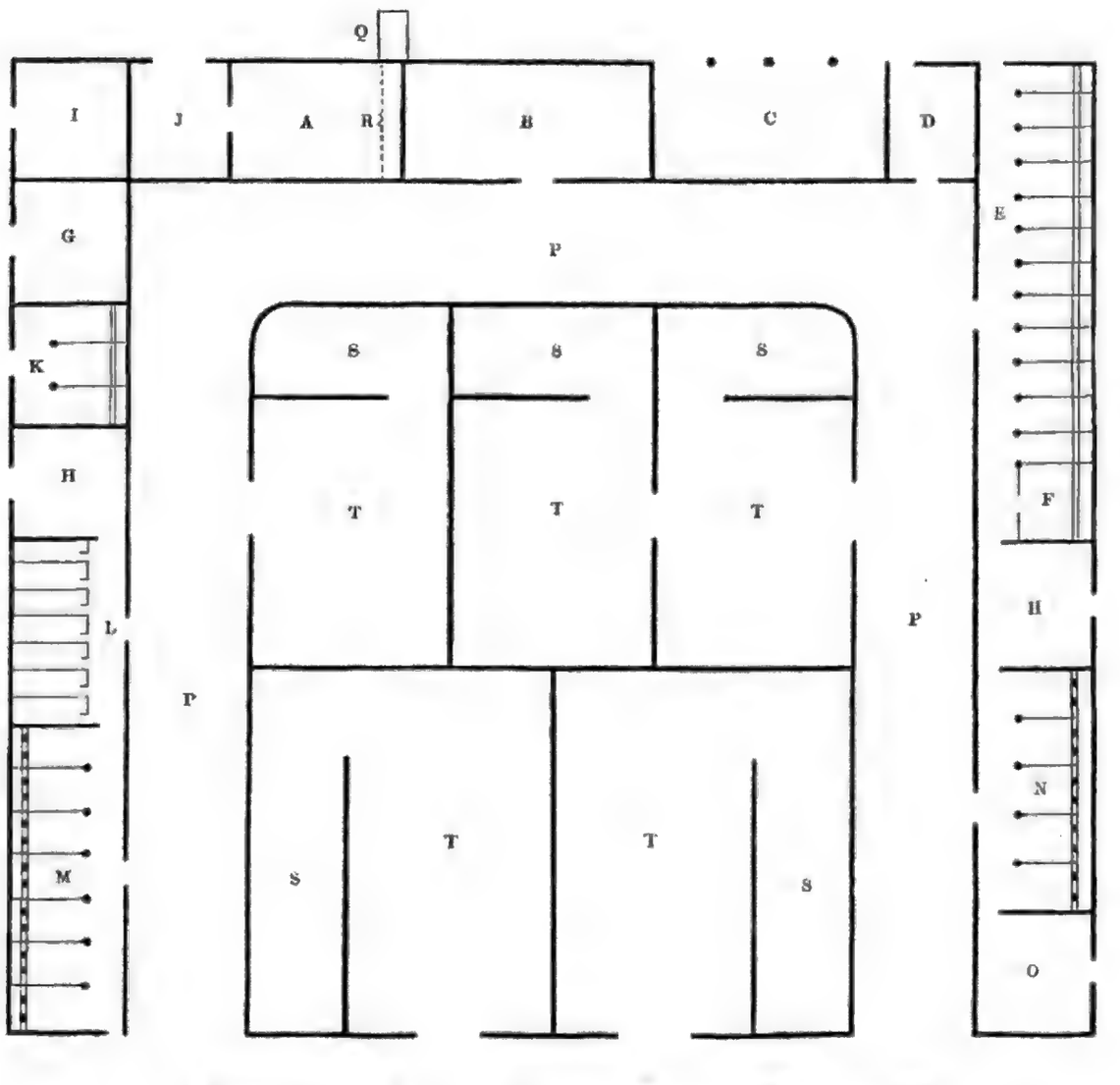
General mistakes

or the cultivation of the soil, and the increase of the quantity of produce.

Best forms.

In the best shapes of farmeries, the form of a parallelogram is preferred, with the front open to the south, so as to admit the beneficial effects of the rays of the sun, and without any houses being placed in front, which would exclude that enjoyment. The building consequently consists of three sides or wings, with interior accommodations. For the purpose of illustration, we are able to give three designs of farmeries for extents of land from 200 to 500 acres, which may be increased or diminished so as to suit any intermediate size of a farm.





A Barn.
B Straw Barn.
C Cart-shed.
D Tool-house.
E Stable.
F Box.
G Gig-house.
H Hay-house.
I Store-house.
J Gangway.
K Riding-stable.
L Calf Pens.
M Cow-shed.
N Feeding-house
O Root-house.
P Road.
Q Engine.
R Machinery.
S Sheds.
T Yards.

Farmery No. 1. Plan No. 1 exhibits the accommodations ranged in the order that has been mentioned, and with an interior road between the buildings and the yards. The room thus occupied has been made an objection, but it yet remains for decision if it be not the readiest access to every situation, and the most convenient arrangement yet devised. The dwelling-house of the farmer is supposed to stand on the west side of the farmery, and, with the garden behind it, will equal the extent of the range of conjoined buildings. The west wing is occupied with a cow shed, calf pens, hay house, riding stable, and gig house: these appendages will be convenient to the purposes of the farmer's domestic use. The walls are 10 feet high, and made with mortar, stones, or bricks. The cow shed and stable are pitched with stones; the other houses have earthen floors. The north wing is formed of houses of the height of two stories, and are a spare house, gang-way, thrashing barn, straw barn, cart shed, and tool house. The walls are 24 feet high, and the whole range of buildings is floored with joists and boards, at the height of 14 or 16 feet from the ground. The floor of the barn is of boards; the other houses have the floors of earth. The east wing of the farmery contains a stable for the work horses, a hay house, a feeding house, and a house for holding roots. The walls are 10 feet high; and every house, and also of the west wing, are open to the top in the inside, and have no floors over the tops of the walls. The horses enter and leave the stable by an end door, which does not disturb any yard where cattle are confined.

Arrangements. The interior room of the farmery that is contained between the three wings, is diminished by the road, which is 20 feet in width, and the remainder is divided into yards for store and for feeding cattle, as shown in the plan. The road is pitched with stones, and the yards are dug in the bottom to the hard concretion that is beneath the soft soil. The shelter sheds are twelve feet in width, and low in the roof. The ricks of grain stand on the north side of the farmery, and are carted to be thrashed into the gangway, whence the sheaves are thrown on the second floor of the barn, where the machinery is at work: they are immediately handed to the person who feeds the scutchers.

The piggery and poultry yards are made separate designs, and are placed as shown in the plan: the piggery on the east side of the farmery, and level with the front of it; and the poultry yard in the centre of the farmery, and in front of the whole erections. The walls being low will not intercept the sun from shining on the yards of the farmery. The

Piggery. piggery breeds and feeds swine on a large scale, as every extent of land in use ought to be held as a manufactory of raw and finished produce. The boar and brood sows are separately and singly accommodated, and the store pigs have a large yard well littered, with shelter sheds, and a pond of water in which to roll and wallow. The feeding hogs are two in a sty, and are there fed with steamed potatoes mixed with meals, which are prepared in the cooking house, as shown in the plan. A light iron waggon on four wheels conveys the food along the

passages, which are laid with flags. The store pigs are fed in the yard during summer with clovers and vetches, and in winter with potatoes, turnips, and beet-root, raw or steamed, or in both conditions.

The poultry yard shows a house for each kind of animals, and a hatching house for all sorts. The young broods are conveyed to small cribs, and there confined till grown strong to go abroad. A fire-house cooks the food in steamed or boiled potatoes, which are given to the poultry along with dry grains, in troughs, in the shelter sheds, which protect the animals from rains, storms, and suns. A pond of water in the centre floats the ducks and geese. Poultry in turkeys and hens are natives of hot countries, and require much warmth; and hence, the great fecundity of poultry that roost in labourers' cottages, and enjoy the heat of the dwelling. In the plan now given, the houses are heated by pipes from the boiler of the cooking house, that convey heat to stones in cast-iron pots below the floor, which retain heat for a long time, and impart warmth to the whole apartment.

Poultry yard.

An arch may be raised over the south-end of the roadway, on which a pigeon-house may be placed, and the top surmounted by a clock. This latter appendage is very useful for maintaining order and regularity in the operations of business. The floor of the pigeon-house may be of boards, and hung upon hinges, which will let fall the floor when necessary and discharge the excrements on the ground beneath. This provision will save the inconvenience of intruding on the pigeons, and the trouble of collecting and heaving the quantity of excrements.

Arch.

Pigeon-house.

Plan, No. 2, shows the buildings arranged, as in the last design, but a very wide difference in the interior of the farmery. The road of access is placed outside the two wings of the buildings, and the feeding yards are in consequence advanced close to the walls of the houses. The shelter sheds are placed in two central rows, between which a railway runs from the stores of roots in the rick-yard through the straw barn, and conveys potatoes to the cooking house of the piggery and poultry yard, and turnips to the cattle in the sheds, which receive the roots through holes in the wall. This facility of conveyance saves much labour in cartage and manual work. Straws for litter and hay for provender are conveyed on the same passage. The piggery and poultry yard are joined in this plan by which one cooking house serves both departments with the steamed roots for being mixed with meals. The buildings being low in the walls, will not much obstruct the rays of the sun from shining on the yards of the farmery.

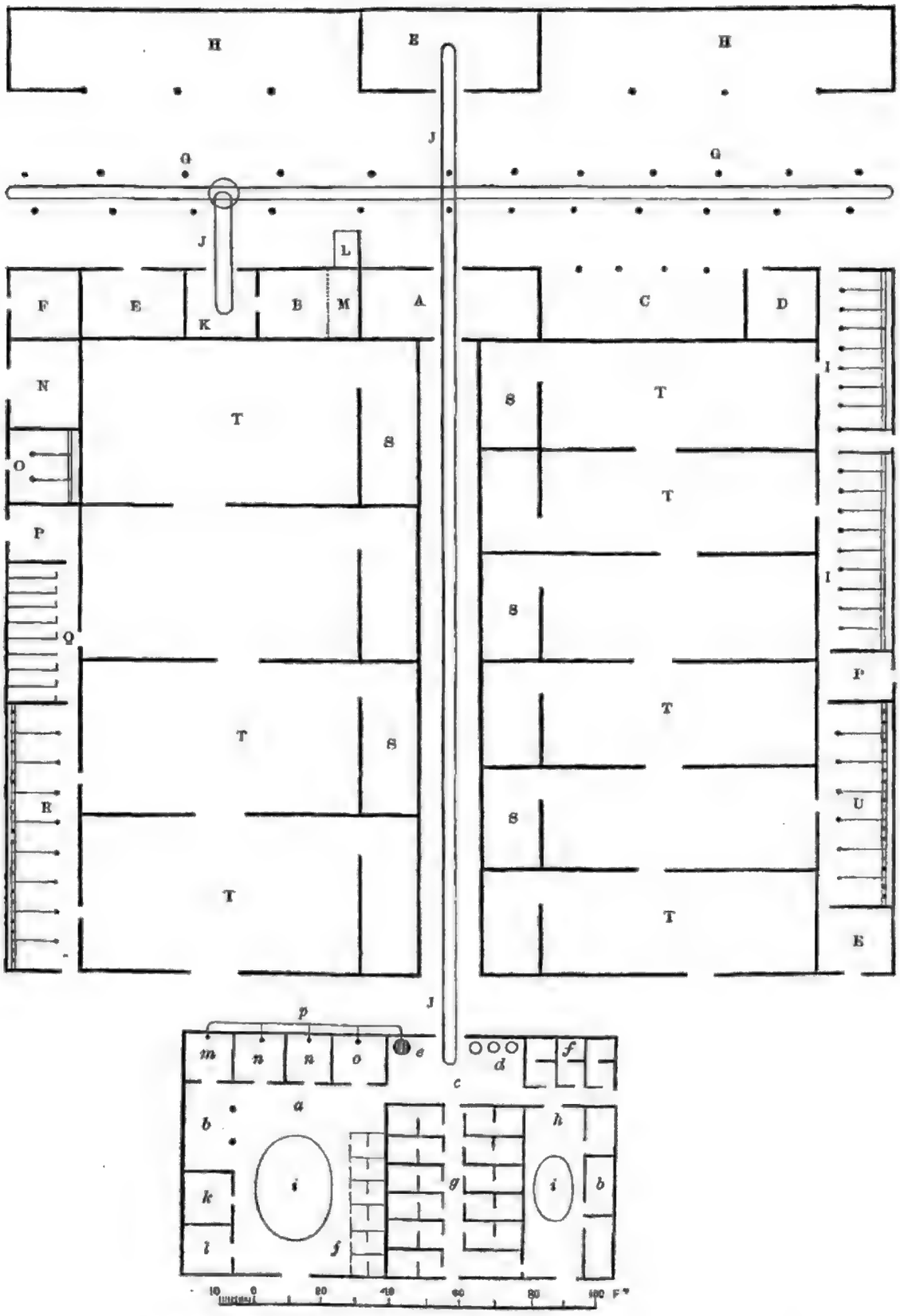
Farmery, No. 2.

The ricks of grain stand in two rows, which extend the width of the farmery, and between the rows a railway conveys on a light waggon of four wheels the unthrashed grain to the machinery, and is turned into the gangway by a turn-table on the main line of rail. The ricks may not be thatched, but are covered by a roof of corrugated iron, which extends over both rows, and rests on cast-iron pillars, which stand on each side of the rows of ricks. The introduction

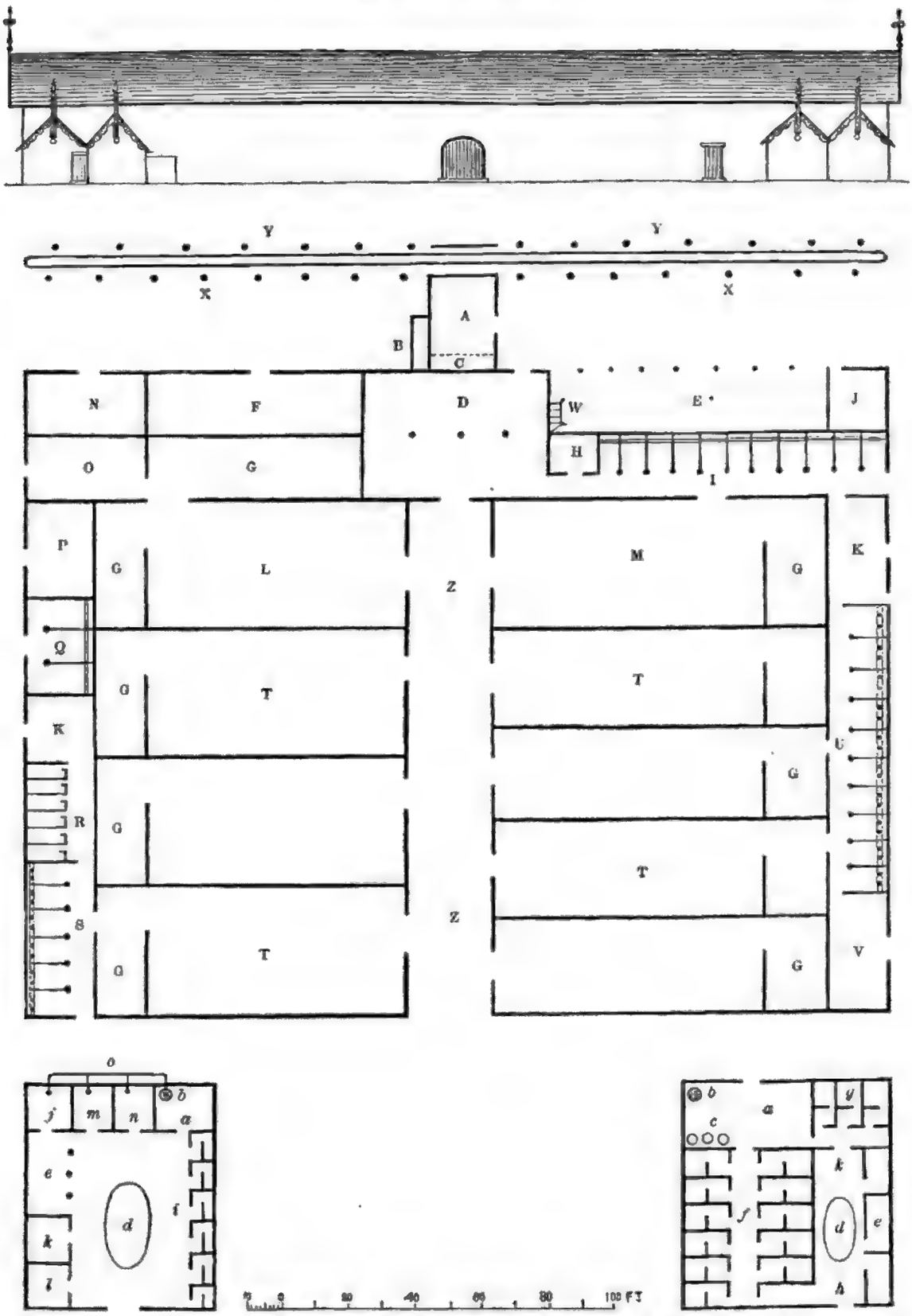
Ricks of grain.

Railway.

of railways is a great improvement, as it strengthens power and dispatches business. This design of a farmery possesses much merit.



A Straw Barn.	H Store-shed.	O Riding-stable.	*Poultry Yard and Piggery.*	*f* Sties.	*m* Roost.
B Barn.	I Stable.	P Hay-house.	*a* Yard.	*g* Feeding sties.	*n* Hatch.
C Cart-shed.	J Railway.	Q Calf-pens.	*b* Shed.	*h* Store-yard.	*o* Turkeys.
D Tool-house.	K Gangway.	R Cow-shed.	*c* Food-house.	*i* Pond.	*p* Pipes.
E Root-house.	L Engine.	S Sheds.	*d* Vats.	*j* Cribs.	
F Spare-house.	M Machinery.	T Yards.	*e* Fire.	*k* Ducks.	
G Ricks.	N Gig-house.	U Feeding-house.		*l* Geese.	



A Barn.	I Stable.	O House for provender.	V Root-house.	*b* Fire.	*j* Turkeys.
B Engine.	J Tool-house.	P Gig-house.	W Stairs.	*c* Vats	*k* Geese.
C Machinery.	K Hay-house	Q Riding-stable.	X Railway.	*d* Ponds.	*l* Ducks.
D Straw Barn.	L Yard for young horses.	R Calf-pens.	Y Ricks.	*e* Sheds.	*m* Roost.
E Cart shed.	M Yard for store Pigs.	S Cow-shed.	Z Roads.	*f* Feeding-shed.	*n* Hatch.
F Spare-house.	N House for bull and stallion.	T Yards.	*Poultry Yard and Piggery.*	*g* Sties.	*o* Pipes.
G Sheds.		U Feeding-house	*a* Food-house.	*h* Store-yard.	
H Box.				*i* Cribs.	

Plan, No. 3, exhibits all the houses of the farmery ranged in two rows, having separate roofs, with a longitudinal valley over the central wall.

The shelter sheds form the inside row of buildings, and the north wing of the farmery is composed of the houses in two rows that usually occupy that position. A central road leads to the straw barn, and along it, by cart or railway, roots are conveyed to the yards and piggery, and straws for litter from the straw barn. This house occupies the width of the two rows of buildings, and is large and roomy: it receives the straw from the thrashing barn, which stands at right angles with it, and this position gives opportunity in the straw barn of making any divisions of the kind of straw. The ricks of grain stand in two rows, as in last plan; the unthrashed grain is conveyed along the railway to the end of the barn, and is pitched from the waggon to the second floor, on which the machinery is at work. This arrangement of the rick-yard and barns is much the most convenient of the designs now given, or probably of any that may be devised.

Farmery, No. 3.

Ricks on a platform.

It is proposed that each rick of grain stands on a square platform of four wheels, which rests on a short branch railway at a sharp angle of divergence, along which the entire rick runs to the barn when it is wanted to be thrashed. Any rick may be thrashed that is wanted, as the way to the barn is wholly unobstructed, and the platform, after its load is disburdened, is sent back to the position on the branch railway, where it receives in the end of harvest another rick of grain from the fields. This plan might deserve a fair trial.

Thrashing machinery.

The thrashing of grain is in every case performed by machinery, which is best impelled by the power of steam. The absurd prejudice is here discarded that the use of machinery diminishes labour, and the latent barbarism of the mind is expelled which continues the thrashing of grain by means of two sticks tied together, and employs labour on a non-productive point. Machinery increases labour, and performs the brutifying parts of the operations, so far as the application is possible. The thrashing machinery of every farm is provided by the landlord as part of the fixed furniture of the farm, and upheld in use by the tenant. No fixed utensil should be removed by the change of occupiers, as when the machinery belongs to the farmer.

It has been proposed to cover a farmery wholly under one roof, like the terminus of a railway. The dung would be thus protected from rains and scorching suns, and the animals will live under a uniform temperature. The roof of corrugated iron would rest on cast-iron pillars, and be extended in separate tiers along the greatest length of the farmery. In exposed situations, hollow cylinders may be formed in the concavity of the roof, which will convey the wind harmlessly over the buildings. It is doubted if it would be beneficial to exclude the influence of the sun altogether from the farmery; the warming effects may not be compensated in the absence by the exclusion of heavy rains. Colds and currents of wind are generated under lofty roofs, but which may be removed in this case by a close walling round the farmery.

Farmery covered as a railway terminus.

Slates form the best covering that is yet known for roofs of houses; tiles are the next best article; asphaltum-paper, and some other substitutes have not come into reputation.

The coarsest glass yet made is too dear for the purpose of roofing; but as there is a general tendency to cheapen the prices of articles, and extend the sphere of their use, the time may not be distant when roofs are wholly made with that article. A most notable specimen is just now exhibited in the circular roofs of glass resting on rounded rafters of bended deals, like the springs of a carriage, which stretch the railways at the terminus of the lines. Those mighty exertions of capital and intellect offer to view very many lessons to be learned, and performances to be adopted, when pride will allow imitation, and conceit perceive its ignorance.

Aspect and exposure.

The aspect and exposure of farm buildings deserve some consideration. The position of the farmery should evidently be central, but many hindrances will prevent that selection of the site: as proximity to a public road, a convenience to water; and shelter will, in many places, very much influence the choice of the position. The situation should be dry, or can be easily made so; the approach not difficult, or can be made convenient without any heavy expense. The exposure should be low rather than high, and have an open front, whence there come enlivening heats and currents of refreshening air. The aspect may be fixed to the south, as being the most benign quarter of the heavens in the British isles; the west is boisterous and wet; and the east, though cold and dry, is favoured with the rising sun; and on that account becomes preferable as a deviation from the south. The subjoined quotation will show that, even in the benign climate of Italy, the proper aspect of the farmeries did not escape the notice of the Roman people:—

South-east preferable.

"Ædificium meridianam partem respiciat, in primo angulo excipiens ortum solis hyberni, et paululum ab occidente avertatur hybernali. Ita proveniet, ut per hyemen sole illustretur, et calores ejus æstate non sentiat." *Palladius de Re Rustica.* Lib. I., cap. viii.

The front of the buildings being low in the walls and turned to the east, the low suns of winter will shine upon the yards; and during the fierce and scorching heats of summer, the meridian blaze will have lost its power over the extent of the farmery by reason of the averted position. The best aspect ranges from west to east, and the intermediate points will accommodate almost any situations in Britain.

Cottages.

Cottages or dwelling-houses for labourers, are an object of very great importance, and form a point of much consideration. Labour is the source of every gain; and it is most just and equitable that wealth, which is the accumulation of labour, be used in providing comfort and competence to the springs of its existence. But the very slow and gradual upward progress of the social system has not yet brought labour and the actors of it into the proper degree of the very just estimation; and the condition of labour yet rests almost wholly dependent on the benevolence of the wealth of the upper grades of society; and that power never can be more beneficially or agreeably employed than in affording comfort to its fellow-creatures.

The present accommodation of the agricultural labourers forms a very great blot on the rapidly improving social economy of the present day. Till of late years the hovels of the working class never attracted any

notice, large families being confined in a single apartment of sixteen feet square, where the common decencies of life cannot be preserved. The promiscuous intercourse of age and sex at all times and on every occasion violates the feelings of propriety and decorum, and engenders immorality that is seldom forgotten during the after-life. Filth and stench abound where cooking and sleeping are done in conjunction, and the roofs being low, a foul air is constantly respired, and the very healthy enjoyment is denied of breathing in a large volume of the surrounding atmosphere. Such dwellings resemble the stalls of a stable, where the animal performs all the functions of life in one apartment. A house with one door for ingress and egress of every article never can be clean, and will be very deficient in ventilation from the want of a current of air that is produced by openings in the opposite sides of a house.

Deficiencies of them.

These very glaring deficiencies are now being noticed, and the remedies suggested and applied. The decent separation of age and sex is the first step in the arrangements of civilization among human beings that are located in permanent dwellings. This very obvious truth requires that any human dwelling consists of at least two apartments on the ground floor. The same necessity of separation demands that the sitting and sleeping apartments be distinct; and experience has shown that bedrooms are much more dry and comfortable when placed on a second floor from the ground: hence, every cottage must have a second floor.

Improvements gradual.

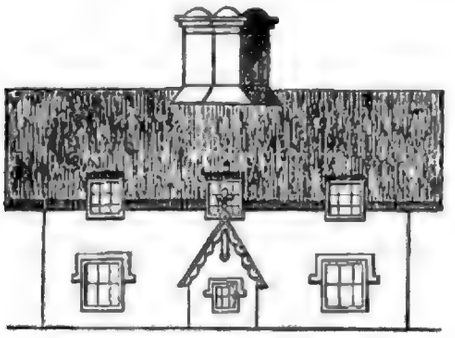
It would be a very useless undertaking to make dwellings beyond the means of being supported, or to raise expectations beyond the power of being realized. The present ideas must only lead a step in the progress, and point the way to a further advancement; the conditions of the social arrangement must always be considered, and the upward progress must be ahead rather than behind the state of the system. The present state of things will sufficiently warrant the essential requisites of a labourer's cottage, that every habitation have two apartments on the ground, of which one serves for the sitting and cooking department, and the other for better purposes and occasions, that the bedrooms are placed on a second floor of joists and boards, and that there be some small back buildings as minor accommodations for the purpose of works that would incommode the dwelling, and also to conceal articles that never should be seen. These principles, in three requisites, form the basis of the following details, in which are implied the cottage having a door in front, and another opening backwards, and a height of wall that admits a large volume of air to traverse the habitation.

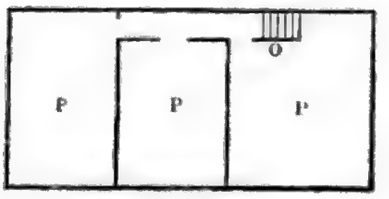
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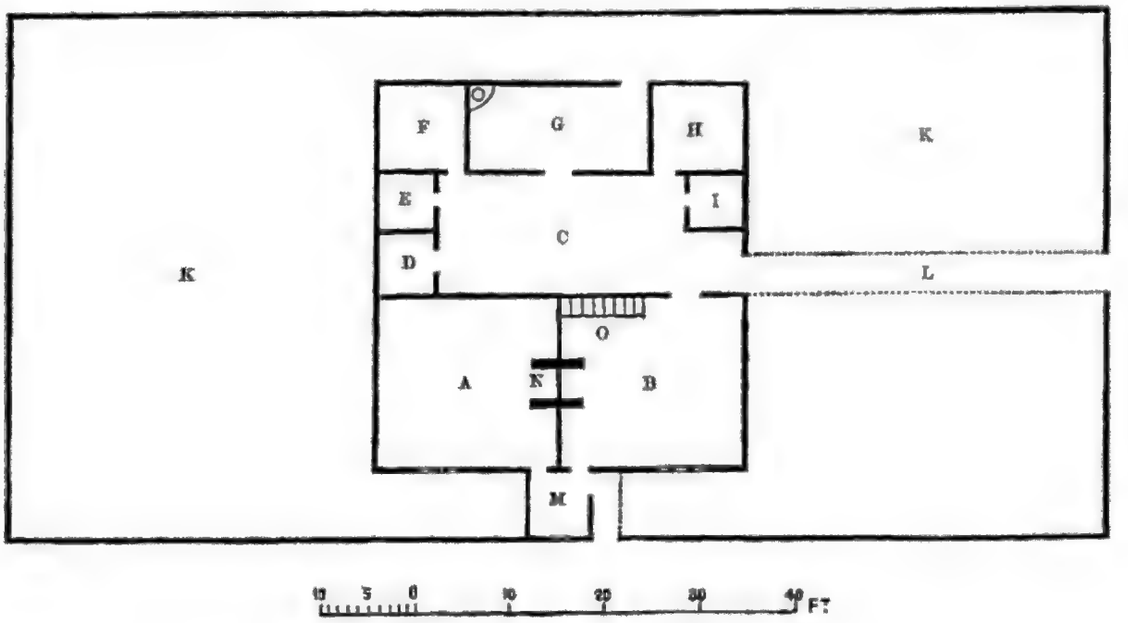
Subjoined are the plans of three cottage dwellings that are arranged on the above principles, and which are not attended with any unsuitable decorations or a lavish expenditure.

Plan, No. 1.

Plan of cottage, No. 1, is a single dwelling for one family, with the proposed accommodations. The ground floor contains two rooms with opposite fire-places, and the stair rises from the kitchen to the second floor. A porch in front breaks the uniformity of bare walls, and affords some little inside room. The walls of the cottage are 14 feet high, leaving 10 feet for the height of the ground floor, and 4 feet to the

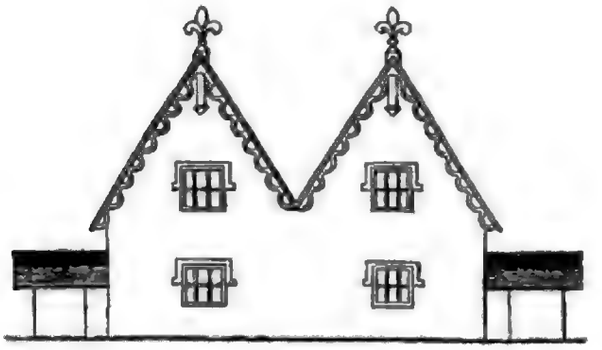


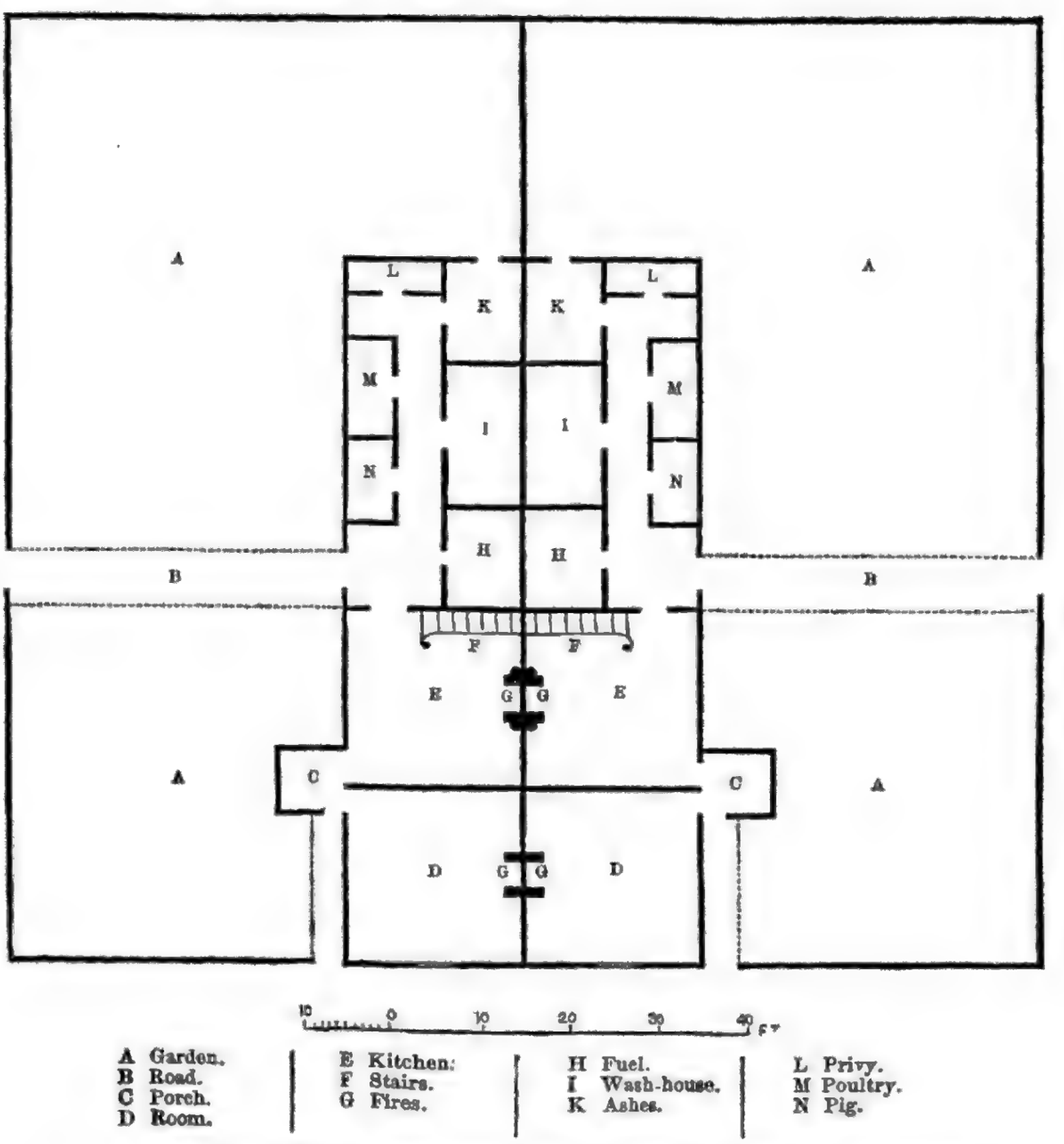




A Room.	E Pig.	I Privy.	N Fires.
B Kitchen.	F Poultry.	K Garden.	O Stairs.
C Yard.	G Wash-house.	L Road.	P Bed Rooms.
D Dog.	H Ashes.	M Porch.	

sleeping floor, which is placed in the roof in the remaining height to make apartments. The windows are in the roof. The second floor is divided into three bed rooms, as shown in the plan. The back area contains small buildings as lean-tos on a surrounding wall of 8 feet high, in a privy, ash-house, wash-house, fuel-house, poultry-house, and pig-sty. The contents of the privy and wash-house pass into the ash-pit, and form a good mixed manure for the surrounding garden, which contains $\frac{1}{8}$ or $\frac{1}{6}$ parts of an acre. This appendage is most necessary to the cottage for growing vegetables, and to afford an agreeable recreation to the cares and toils of life.





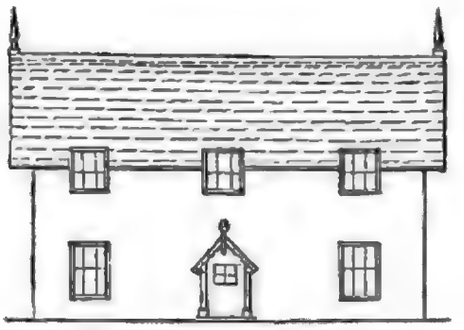
A Garden.
B Road.
C Porch.
D Room.

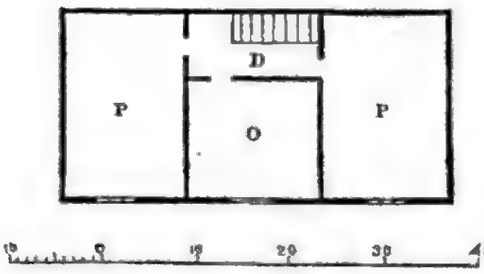
E Kitchen.
F Stairs.
G Fires.

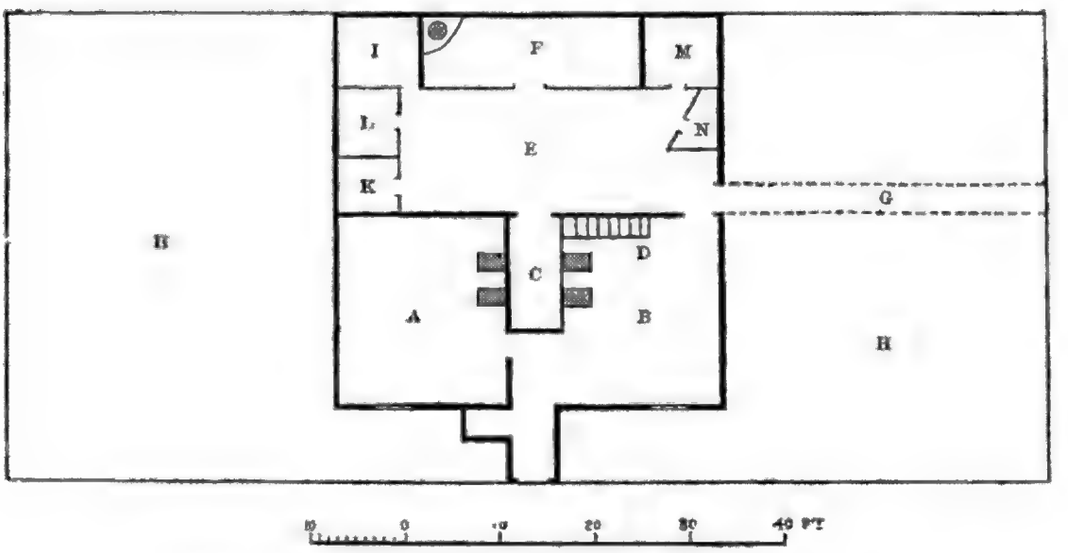
H Fuel.
I Wash-house.
K Ashes.

L Privy.
M Poultry.
N Pig.

No. 2. Plan, No. 2, shows two cottages that are joined longitudinally, and have the ends for front. The porch is in the side of the house, and enters through the garden. The accommodation and arrangement are the same as in last design, and the back area has the same small buildings. The garden surrounds the cottages, and a road leads to each dwelling through the garden.







A Room.
B Kitchen.
C Poultry.
D Stairs.
E Yard.
F Wash-house.
G Road.
H Garden.
I Fowl.
K Dog.
L Pig.
M Ashes.
N Privy.
O Bed Closet.
P Bed Rooms.

No. 3.

Plan, No. 3, shows the design of a single cottage, with the poultry-house placed under the roof of the dwelling, and betwixt the fires, of which the heat will convey a very agreeable warmth to the animals. This provision will largely contribute to the laying of eggs and the hatching of chickens throughout the year. The other accommodations are similar to the last plans.

The entire site of the cottages is excavated to the depth of two feet, which is filled with stones of the convenient size and flatness to form the foundation of the building; and below the brick floor of each apartment there is one foot in depth of broken stones, which will render the cottage very dry underneath.

Expense. The cost of the single cottages in each dwelling will vary from £80 to £100, according to circumstances, and the two that are joined will cost about £180.

Groups of cottages. Groups of cottages have been devised—square, circular, and polygonal, and containing six to twelve dwellings in one congregation, with a garden attached to each habitation, and having a pump of water and a bakery to serve the whole of the families that dwell in the house. But lazy assemblages are created, and much idle gossiping is encouraged; and it is preferred to have not more than two cottages in connexion, and the fronts averted from any close communication of business. The gardens are best when closely joined to the dwellings, both for pleasure and usefulness.

For a variety of choice and selection on the subject of farmeries and cottages, the reader is referred to "*Donaldson's Improved Farm Buildings*," and "*Designs of Cottages*," by the same author. This work may be had of the publisher of this book. The book of farmeries contains designs for farms of 50 to 1000 acres—square, circular, and polygonal, and embracing much variety of design. Farmer's houses accompany the farmeries, and also a number of cottages. The book of 40 designs of cottages comprehends these habitations only, and exhibits a large and useful variety of design and invention.

Books of reference.

The cost of the erection of farm buildings varies from two to five years' rent of the land; the calculation being liable to the usual variations by circumstances that affect all such arrangements. Employers very much neglect their own interest who omit the provision of affording the labourer pleasure after pain, and of giving some little solace to the cares of poverty and toil. A commodious lodging is equally required with the payment of the wages of labour, as without it the value does not appear, nor is the desire properly excited to the future development. The spirit sinks when the relish is withheld of enjoying the hard-earned rewards of toil, however small they may be, and no earnestness can be reasonably expected, nor can any anxiety be manifested, when the small indulgence is denied the labourer of having a comfortable fireside and a warm bed in which to recruit the body and refresh the spirits for the coming exertions. Negligence and inconvenience aggravate the filth of poverty, and put to flight every idea of living in the vicinity.

Necessity of comfortable dwellings.

Land-owners lose the value of their property by not providing the ample fixed appendages of the farm on which the tenant uses his floating capital, and the labourer exerts his share in the bodily performances. In the former case he loses the present value, and in the latter he fails to obtain the attachment and esteem of the ground-work of society, on which the whole superstructure leans for support. It is only to be got by just rewards and kind treatment, and must not be neglected if the higher grade of existence be contemplated to endure.

Value is lost by the want of them.

CHAPTER V.

LAYING OUT FARMS, ROADS, FENCES, AND GATES.

In old inhabited, thickly peopled, and highly improved countries as Great Britain now presents in the cultivable surface, no opportunities occur, except in the few cases of enclosing large commons, of making an original formation of farms. The form should be as compact as possible from the attending circumstances, for time is saved in the tillage, the expenses are lessened in several ways, and the superintendence is rendered more easy; the boundaries should be as straight as can be obtained, and curved only to suit the bends and sinuosities of the surface of the ground. The courses of rivers and of large brooks of water, the line of roads that are drawn for public use, the access to water, and the provision of shelter, will all be entitled to due consideration, and must have much weight in determining the division of land into fields, the size of the enclosures, and the exposure of the grounds. A variety of soils will also happen to disturb a regular uniformity; it is very highly eligible to join with clay lands a portion of turnip soils, and these again must be divided by the fences of the farm in order that the same field may not undergo two processes of cultivation, nor produce crops of different kinds. It is convenient, when a public road intersects or runs along some part of a farm of land, when the access is convenient to the business of the occupation, and the road may very beneficially form the boundary of two contiguous farms. Rivers, roads, plantations, and stripes of trees constitute the divisions of lands in cultivation, as the passage is generally troublesome, and the distance inconvenient. High and low grounds are often required to be joined in the occupation, in order to attach grazing grounds with arable lands, and to afford the shelter of the valley to the exposure of the hills. Many variations must have attention, and much consideration and weighing of circumstances are deserved by the very important purpose of allotting grounds for the convenient and effectual cultivation.

Position of farms.

Much varied.

Few or no general rules can be laid down with respect to the size of farms. In practice the size of farms must be made to suit the demand, the condition of the tenantry, and other circumstances.

Size very various.

In the vicinity of towns, the quantity of lands will tend to be small in the single occupations. The cultivation is market-gardening rather than farming, and the demand is for articles, in the raising, transport, and disposal of which a minute care is necessary. The rent is high, which

represses the size of the extents of land, as the articles sell dearly, the sale is ready, manure is at command, the produce is quick in succession, and a smaller capital is required. But when land is removed from a convenient distance from towns or marts of small quantities of produce, which are sold in retail, the rent will be very much less, and the management will be conducted under very different circumstances; the produce will be chiefly in grain and live stock, which will be more cheaply produced, and sold in considerable quantity.

Nearer towns

One very general rule may be stated, that no farm of lands shall be less than employs one plough with two horses to perform the yearly labour. This quantity will be forty or fifty acres, as the soil may be clay or turnip land. Below that extent the condition of a tenant of land descends to the common labourer, and even that quantity does not raise the occupier above the servile employment of bodily labour, as the quantity of capital that is used cannot command a profit that is sufficient to maintain an idleness. The quality of the soil, the opulence of the district, and the benignity of climate, and the geographical position, will very much determine the size of farms; and while no doubt can exist, of the general superiority of farms of sufficient magnitude, it is not by any means advocated, that the size of farms must be increased and indefinitely, either for the individual interest of the land-owner, or for the public benefit. It is quite certain, that the example of beneficial improvements has always been set by extensive farmers, who are persons of capital and education, and enjoy a station that places them above vulgar prejudices and local conceit. But a variety in the extent of farms is suited to the variety of demand, which is generally greatest for small possessions; and landlords often do not much heed these regulations, provided a good rent is conveniently obtained. The spirit and enterprize of the larger farmer are often outweighed by the greater frugality and attentive detail of the smaller tenant; and the compensation is often surprising when the disadvantages are considered under which the smaller tenant labours.

General rule.

The dimensions of farms are frequently increased from large extents requiring less expenditure for buildings and enclosures than small possessions; but there is danger by so doing in placing the lands beyond the reach of the farmers around. A continued extension of this kind may place particular farms beyond the reach of the common capital of farmers, and the demand may be very much lessened when they are brought into the public market.

Large farms.

Pastoral or hill grazing farms must be extensive because a large surface is necessary to yield a good return, and different animals require to be kept on the grounds, which cannot be done without sufficient space. The expense is less in managing these large congregations; a greater number of animals can be bought and sold at a time, and few or many shepherds are equally capable of being managed, and of bestowing their superintendence.

The tendency of farms to increase in size, shows the improving condition of a tenantry and a sub-division of lands implies a declining

condition, or a defective connexion between them and the land-owners; capital is shown to be wanting for the purposes of cultivation, and the tenantry to descend into a worse condition. A regularly continued progress of sub-division of lands will ruin any country, as is seen in the case of France, on the score of ownership; and in tenancy, in a great part of Scotland, in many remote districts of England and Wales, and over the whole kingdom of Ireland. Such a state of things is most peculiarly unfavourable to the progress of agriculture; and the increase of the farms in size will be the first symptom of revival, for it will show that funds have begun to be acquired, and that a superior class of tenantry will be established. Every progress of agriculture has increased the extent of the holdings of land, and if ever the tenantry of Ireland rise above their present condition of starved and ill-requited labourers, the existing possessions of land must be formed into extents that can be cultivated with effect. Such changes are gradual, and require much time; the evil has been extending for generations, and as many more may pass away before a suitable allotment is seen of the land for cultivation, and the substitution of a class of spirited and independent yeomanry for the present unfortunate occupants of the cabin and the bog.

Condition of tenantry tends to increase the size of farms.

Minute subdivision always hurtful.

Roads are artificial pathways formed on the surface of the earth for the transport of heavy bodies, and as the natural ground is soft and yielding, it becomes necessary to protect the tracks from pressure and attrition by a covering of some harder matter, as pavement, small stones, or gravel. The first article is costly, and not to be found in many places; gravels are worn round by the action of water, and the small pebbles never bind together to form a compact bed of road, and consequently stones broken small by the hand-hammer, which are got from a quarry or from surface stones, are the most useful materials in the making of roads. The disunited fragments present many angular points, which when acted upon by pressure, are fitted into the alternate shapes, and become almost a solid mass of small particles possessing a broken continuity. These angular points are wanting in gravels, which require to be broken by hammer, and even then the remaining round side prevents the junction so well as in quarried materials. Hence stones of any hard kind have been long established as the most suitable materials for making roads, and broken to the size of passing through a ring of two inches in diameter.

Roads.

Materials.

The direction of roads is an object of very great importance, whether the line be a public thoroughfare, or a cross-road of communication, or a private farm outlet. The inclination of the surface, and the hardness, smoothness, and durability of the covering, constitute the chief properties of a road, the highest of which is a plane with a surface resisting the pressure of bodies, and opposing the least resistance to their motion. Steep acclivities must be avoided in the direction of roads, when high grounds cannot be ascended by a rise of one foot of slope to thirty-five of base, and from that figure to fifty, the line of road must be

Direction.

diverted round the hill, and to skirt the base of the high ground, rising or descending in its course, according as the object to which it leads is situated above or below the level whence the road commences. A circuitous line is certainly produced in this way, but it is unavoidable, as the hills cannot be climbed, nor deep vallies crossed without an overwhelming inconvenience. The vallies that intersect a country are to be crossed by roads at the narrowest point which can be approached, when a bridge will be generally necessary. The cutting of the upper side of a road that skirts the side of high grounds, very conveniently affords the materials for embanking the lower side, and the expense is less than when a road is made on a level plain, where the whole formation is made of raised materials. This line of a road affords a drier bed generally than when the direction lies along low grounds, which may be wet and swampy, and exposed to inundations. A ditch along the high side of the road intercepts the waters from the high grounds, and conveys it to stone culverts which cross the road at the proper places for discharge.

Cross Roads.

In every case where the advantage can be obtained, the hard materials that compose a road, should be laid upon the grass turf, as it presents a tough and matted surface which resists the pressure, and prevents the broken stones from sinking into soft ground. But when excavations are made, and embankments formed for the passage of a road, that advantage is not got, and the materials are compelled to be laid on the newly-formed bed of fresh earths, which are mostly soft, and yield to the pressure. In that case, the hardest and driest materials that can be got, are selected and laid in an even surface below the track of the road and broken to a small size. Over it is laid a body of broken stones, which were before mentioned, in the depth of twelve inches, and width of twenty feet; and this space is bounded on each side by a sloping ground of twelve to fifteen feet reaching to the side ditches which run along the front of the boundary fence. This width of sixty feet is not beyond the use of a public thoroughfare; and the hard materials of twenty feet in width, allow the carriages to change the tracks, and not to follow, as in narrow roads, the same path of wheels, which is a most pernicious accompaniment of a confined space, and very soon destroys the consistency of the road. Convex roads, or having a high centre with sloping sides, are discontinued from an excess of the method of formation, but as much convexity is eligible as will throw the water to the side ditches. Roads must be kept dry, and where wet grounds must be passed, drains are necessary to be placed below the road in three longitudinal cavities filled with broken stones, one in the centre of the road, and the others at the division of the hard materials with the sloping sides of earth. Cross drains are necessary in the hollow places, to convey the water to the side ditches.

Grass turf the best bottom.

Width.

Draining of Roads.

The most public roads are turnpike trusts, with which the land-owner has only a small joint concern, and over which his property control does not extend; but the private roads are his jurisdiction, jointly or singly; and the roads on his farms are exclusively his undivided patrimony and

employment, and deserve an especial attention. When money is collected from the farmers by a rateage, and applied in the making and repairs of roads of a general use, some competent person must be appointed as the permanent overseer, who shall employ labour and collect materials, at the times and places, which shall appear to be most eligible and generally beneficial. The custom is not yet abandoned of the farmers serving in the yearly rotation as overseers of parish roads, and of bestowing so low a minimum of attention as scarcely ever to see the object of their care. The tenure of office is far too short to allow any ideas on the subject, and as it must occupy some time, less or more, an utter carelessness is evinced towards an object of the most primary attention. These district and parish roads are the first divergence from the main trunks, or parliamentary trusts; they are the arteries, and the farm or private roads form the veins of the ramified intersection of a country by the means of communication. The parish roads may be one-third below the width of the turnpike lines, and the farm roads may be one-fourth narrower than the district tracks, making the breadths to be forty feet and thirty feet respectively. The first extent will be divided into sixteen feet of hard materials in the centre, with twelve feet of sloping ground on each side, and the farm road will be fourteen feet in the centre of broken stones, and eight feet in the sides of sloping surface. These widths will be sufficient for all ordinary purposes.

Surveyorship.

All roads must join each other at right angles, with an arc or circular sweep on each side of the junction, in order to indulge the constant tendency of animals and carriages to turn in the intended direction before the whole equipment has reached the road that has been approached. Ample room is better than pillars or railings placed at these points, as the carriages run against the securities in a confined passage, and break the outposts of safety. A strong railing is recommended on the extreme edge of the circular sweep, after a very ample ground has been allowed to render the use of it very seldom required. Parish and district roads have the same object in view as the main trunks, to reach the point of attention in the most convenient and eligible manner: the location of farm roads is directed by the position of the farmery, the formation of the intervening grounds, and to afford access to the adjoining fields of land. The square or parallelogram form of fields must be preserved, if at all possible; if beyond the reach, then a bended or curvilinear shape must be preferred to a polygonal circumference of corners and abutments. In other cases, two sides, or one side, of a field, may possibly be got in a straight—and the others will be directed by the adjoining lines of road, or formations of the ground. It is best when each field of land opens into a hard road, and which prevents the travelling over the soft surface of any field in order to reach the other beyond it, which is often very inconvenient. For this purpose, the breadth of two fields must intervene between two roads, and when this arrangement cannot be obtained, the headlands of the field that adjoins the road, must be made into a road, and kept for that use. There

Junction of roads.

Private roads.

Between every two fields.

is a greater necessity that straight lines be preserved in the placing of farm roads than in the direction of the main trunks; the latter have only one object in view, while the private purposes have several contemplations. Still the roads may be located in places such as are found to be low grounds, and at such distances as will shape the fields in the oblong direction, along the line of the private road, or stretching across between the two roads. The equal size of fields of land is also to be preserved as much as possible; and the best experience has fixed the size of twenty acres, or varying from fifteen to thirty, as the most suitable extent of divided lands, for the purposes of arable or grazing husbandry. Small enclosures create too many fences and gates, and incur an expense in the upholding and repair; and large fields are in many instances much exposed from want of shelter, and require too large a number of animals for the pasturage, and small flocks of beasts always thrive best. The access to water will have much influence in determining the extent and position of fields, and the most essential article may be procured by forming a pond in the lowest ground, by boring as a well, or by bringing the water from one place to another in a rill, in a covered drain, or in metallic pipes. In the latter case, a trough being placed across a subdivision fence, will supply two fields, and when the grounds are very high in the position, the pasture must be used by sheep, which require little or none of the element of water for the organized development. The shape of fields must not depart far from the square form, or the grounds will become formed into a number of longitudinal slips, that are both unsightly and inconvenient. Corners are in all cases to be avoided; but when the situations are unavoidable, the narrow angle must be planted with trees, and thus make a straight fence of the field. The junction of roads, as was before mentioned, must be at right angles which will direct the joining of the fields to be in the same position in all cases of a contiguity.

Ready access.

Corners to be planted.

It may be very safely affirmed that the making of roads as convenient lines of communication are the first improvements to be done in any country, and the keeping of the tracks in a sufficient repair, is a point of little less importance than the original formation. When roads are in bad repair, the wheel carriages are broken, the animals of draught are distressed, and small loads are transported; circumstances which operate against the prosperity of agricultural undertakings. The landowner has the power of enforcing the proper condition of the parish roads, and the tracks for farm purposes are wholly and absolutely his own performance. No fixed appendage of the farm possesses a higher useful value than an ample sufficiency of well-made roads, nor will any enlightened practical man neglect to examine and estimate the convenience which his floating capital will enjoy in that respect: he will use his judgment in comparing the advantages which are presented by different situations, and make his choice by the greatest number of facilities that are offered for the employment of his money and his time. The approach to the main trunks of communication is the first

Roads a primary improvement.

great value to any farm.

attention, and then the access to each field from the farmery, which is the focus of the whole movements. The finest farmery that can be devised and erected, may be rendered of small utility when the application of its merits is withheld by the want of the ways of traffic; when the loads must be restricted in weight, and the frequency of the transits is limited. Practical men know full well the drawback of these prohibitions, and will not fail to place them on the proper side of the account in reckoning the sum of the intended offer for land to be used in cultivation. It becomes the interest, and also the duty of the landowner, to have the farms of land unobjectionably provided with convenient and well-made roads, as well as with buildings for habitations. The means of transit must be very ample and ready, and no want must appear that can hinder the full per centage being given to the owner of the soil for the interest be has purchased in it, from allowing the floating capital of the tenant the beneficial and prosperous opportunity of use, and from employing and maintaining labour, which is the paramount and overruling consideration of every object and design. Any neglect on these points baffles the fulfilment of the intended purpose, and destroys the arrangement of the joint performances.

Always noticed.

The maintenance of farm roads in the proper repair devolves on the farmer, who must support the bed of hard materials, and keep the side ditches clear as currents for water. This charge is seldom expensive; the field stones that are periodically gathered, serve as broken materials, and the earthy scourings of the side ditches are generally useful in compost with lime for making a manure of very considerable value. The farmer's own interest must ever induce him to perform these operations. The smoothness of roads for his carts and horses, and soaked earths for manure, are worth the attention of every cultivator that deserves the appellation.

Good repair indispensable

Fences are barriers raised betwixt the fields of land for the purpose of protecting the crops that are growing in an enclosure from injury done by the animals which are grazing in the adjoining division. They also serve the purpose of separating the flocks of animals, and enable the production of different plants and crops in the required divisions without any mixture or confusion. Lowland arable farms require to be closely and permanently subdivided by lasting boundaries, while upland farms and hill grazings are only provided with a general fence which surrounds the whole farm, so as to protect the grounds, and save the sheep and other animals from disturbance. Large flocks of mountain sheep do not require any minute subdivision, but are spread over an extensive range of surface. Lower pastures that have some tillage lands, are divided in the crops from the grazing grounds; and near to the homestead, there will be two or three paddocks or small enclosures for the rams of the flock, for weak ewes, and similar purposes. The comparative small value of the surface ground prevents the extension of enclosures in a practical view; but where the ground increases in value, a greater use of enclosures is required, and will be admissible on the score of profit. Sometimes

Enclosed grounds.

Open farms.

the quantity of arable lands in these possessions is so large that another farm is constituted distinct from the grazing ranges, and then the enclosing of the cultivated parts is similar to lowland farms.

Fences are made with stones from the quarry of rocks, or with the gatherings of the field in boulders and slaty fragments. These stone walls stand either wholly above ground in the entire height, or are sunk in an excavation, and form a fence in the front having the top level with the ground behind the slope that has been dug. This last is called a sunk fence. Mortar walls are erected on the sides of highways in the vicinity of towns and other situations that are much exposed to trespass and injury. They are the most complete and durable of all fences; but the cost is beyond a very extended application. The foundation is made with broad flat stones in a firm subsoil—the width of eighteen inches at the base slopes to one foot at the top, which is covered with rough stones set on edge, and projecting over the wall on both sides. The height is from four and a half to five feet.

Stone walls.

Dry stone walls. Dry stone walls, admit a much larger application than the erections with mortar as a common masonry. But even that provision of fences is confined to certain districts which contain suitable rocky formations that are near to the surface of the ground, and easy of access. Schistoze formations are the most eligible, as the laminar fracture produces a form of the fragments that is adapted to the purpose of building walls in which no mortar is used as a cement. The foundation is dug to a firm depth on which flat sided stones are laid in the width of nearly four feet; the wall to be raised is laid on these stones in the width of three feet; the top at the height of five feet from the ground is narrowed to eighteen inches, over which is laid a tier of long narrow rough stones placed on edge, and projecting over the wall on both sides. The sides of the wall are built with the best shaped stones in the manner of the common walling, and the small lumps are firmly packed in the centre. A cope of stones is much preferable to turf which soon moulders away; and it adds to the solidity of the fences in the weight of the stones that are laid on the top of the wall.

Boulders. Boulders or field stones are very abundant in many parts of North Britain, and very good fences are formed with these materials, the shape is rounded, and seem to be a large formation of primitive gravel, and are difficult to be built into walls. The hand-hammer is applied to break the lumps into at least one square side, which is placed outwards in the wall, and the centre is very closely filled with the smaller boulders. There being no large stones to form a coping, the top is rounded with the unbroken stones into a narrow apex, which is terminated with one row of the largest lumps that are found. The sunk fence of these stones consists of only one facing of boulders, as the back rests against the solid bank of earth, which has been excavated in the depth of the fence. Plantations are well fenced in this way, and the top of the fence is level with the surface of the cultivated land and of the planted ground. The top of the wall is covered with turf, as part of the surface of the plantation.

Sunk fences.

Stone walls are called dead fences, and under peculiar circumstances the preference is justly due to these erections as the boundaries of lands, and for the separation of grounds. Less space is occupied by the stone wall than by the live fences; it does not harbour vermin of any kind, and less expense is required in keeping up the dilapidations. But the appearance is dull, and wants the enlivening and cheerful aspect of the blossoming hawthorn, and less shelter is afforded to animals by the wall than by the hedge. Dry grounds which do not require ditches as outlets for water, are best adapted for stone walls, and always with the understanding that the rocks are adjacent to the grounds that are to be fenced; that the access is easy, the rock conveniently dug, and the whole operation capable of being done at a moderate expense. On high exposed grounds, where the climate is outrageous and the soil unfavourable, no care or attention is able to raise live fences, and then walls of some kind are the necessity of the case. Turf walls will last for a very considerable time, when well built at first, and where the climate is moist, and the grassy vegetation ample and strong. But they form no obstacle to the trespass of sheep over the soft materials; cattle rub upon them, and hot suns induce the mouldering and dilapidation.

Walls when useful.

Live fences are the most common boundaries of fields over the greater part of the British isles; and for the purpose of raising the fence of growing shrubs, the most approved plant is the common hawthorn of white blossom. It is a perennial plant, of much durability, and has a large adaptation of growth in different soils and situations. This last quality constitutes a very large recommendation to the use of its application, and where a varied utility is required, the last importance is attached to that property of the article that is selected. Experience has long ago shown most incontrovertibly that the common white thorn is the most generally useful plant for forming hedges: it grows quickly, and on a great variety of soils, and the prickles or spines are very annoying to stragglers that trespass from field to field. The plant is raised in nurseries to the age of three or four years from the haws or ripened fruit of the aged plants, which are sown in beds of fine earths that are prepared for the purpose. The sets are raised for use, and cut to the length of six to twelve inches, as new shoots from the cut end are ever more vigorous than the continuation of the stem produced in the nursery. The line of new fence being determined and marked with planted stakes, a turf is cast by the spade along the line and inverted upon the ground, with one side touching the cord, and the other sloped by the spade from the middle of the turf to the surface of the ground. On this sloped earth of turf, the cut thorn sets are very carefully placed by hand at the distance of four inches from each other, the upper end being even with the high end of the slope. A ditch, in the case of wet grounds, is dug at the width of three feet, and the depth of two feet; and the earth that is excavated is thrown backwards to form a mound. The best earth on the surface of the ditch is placed over the roots of the thorns, the upper ends being left in sight, whence the shoots will proceed. On dry lands no ditch is required, and the sets are placed deep in order to enjoy the benefits

Thorn fences

Erection.

Care when young.

of moisture. The mound of loose earth is raised to a height behind the row of thorn sets, and upon it is placed a fence of strong dead thorns, or better in a paling of three bars of sawn timber, which will last for many years. The front of the young hedge is protected by a similar fence, which is placed in a slanting manner along the side of the ditch, and in this way defends the young shoots from injury. These fences must be upheld and repaired with a very vigilant and constant care, in order that the young thorns are securely protected during the years of tender growth.

During the first two or three years of the growth of young thorns, so many weeds must be pulled away by the hand as will afford room for the young plants, and no more need to be destroyed, as the covering of weeds

Weeds removed.

defends the bank of earth from drought, retains moisture, shelters the plants, and is beneficial to the growth of the thorns. On no account are spades to be applied, as is usually done, to pare away the bank of earth by gradual operations, and expose the roots and stems of the thorns to the influence of sun and drought. After three years, or in less time, the thorn shoots will overtop the weeds, and then no more care is necessary on that point. Some shoots of the thorns will rise much above the other growths, both in height and sideways; these overgrowths are lopped by the pruning knife, but no other cutting or slashing is done; as wherever an incision is made in any vegetable growth, a bundle of feeble shoots are protruded, which divert the juice from the main purpose,

Training of the hedge.

and enfeeble the special growth. Hedges must be allowed to grow in the wild luxuriance of nature to the height of full five feet, when the form may be fashioned into any shape that may be wished; and generally, in the period of eight years, the fence will be complete, and need no protection from accessory aid. A sufficient regularity of height and straightness of sides can be obtained by lopping the overgrowths that appear; and with this small application hedges are best allowed to remain without any cutting or plashing; and the luxuriant blossom of nature's forms is much more pleasing than the dull uniform sameness that is produced by the shears of the clipper. Gaps are to be very carefully filled up from the first year of the growth by planting young sets in the open space, or better by pulling across the gap the young shoots on each side of it, which are fixed in that position by means of hooked pegs of wood driven into the ground. This precaution is necessary in order to procure a close hedge, and unless it be thick in stems and foliage, passages will be made at the weak places, which destroy the utility and impair the value of

No cutting of the growth.

the performance. Hedges never should be cut in any stage of growth in a young state, the progress is retarded by it, and in the advanced condition an expense is incurred which is wholly useless and unnecessary. It only remains to raise a hedge to the required height, and then to keep it in that condition of existence.

Furze.

Furze forms a very good fence in some places, but the plant flourishes only on dry banks, under warm early climates. When the growth rises high, it is apt to become open below, which objection is

partly remedied by having the hedge in two parallel rows, and by cutting the rows alternately, so that one row forms the fence while the other is growing after being cut.

Beech.

Beeches grow well on some damp cold soils, and form a good fence, but the plant is of slow growth, and it wants the formidable prickles of the thorn, which constitute the weapons of defence against the trespass of animals. The hornbean tree is of a similar nature and value.

Sloe.

The sloe thorn, or black thorn, from its very sharp and numerous prickles, forms a strong and durable fence, but the plant is both slow and shy of growth.

Thorn hedges never grow well at gateways, and it is very advantageous to raise a piece of stone wall on each side of the passage, and to insert the thorn roots between the stones, with the shoot end projecting outwards, and from the young shoots growing upwards, very strong fences are often obtained from this mode of inserting the thorns.

All fences raised by the land owner, and upheld by the farmer

Fences of every kind must be first raised by the proprietor of the land, and subsequently kept in repair by the farmer; and nothing more clearly shows a farmer in every sense of the word than a range of fences in a thorough and complete condition of use and efficiency, without any gaps or weak places. Good husbandry never understands a carelessness to be evinced in any one single department on the farm; the most attentive vigilance is to be adopted even in the most minute articles of utility, and the habitual custom must be exercised of keeping all things in use and every thing in order.

Sets laid on grass turf.

New fences of thorns are to be placed, if possible, on the grassy surface of turfy ground, in which the roots of the thorns spread in search of sustenance. The length of the thorn-set fits the sloped side of the inverted turf that was laid to form the base of the fence; one end sends upwards the shoots which form the hedge, and the under end which is covered with earth, projects the roots which nourish the plants. The operations of life are on the surface of the ground, and these processes are engendered by the life and decomposition of the animal and vegetable existences that are in being on the surface of the earth. The roots of the thorns spreading among the decomposition of these minute portions of life, receive a food that is of all others the most favourable to life of any kind, for no manure yet known can be compared with decaying vegetables when in connection with the quicker elements of animal bodies. No ploughing or digging of the ground is required on which a new fence is to be placed.

Hedge-row trees.

A number of trees growing in a hedge-row is no doubt very objectionable, but a few standards in scattered distances enliven the scenery and improve the landscape, and the damage to the hedge is inconsiderable. The distance of 50 or 60 yards seems a proper distribution. It has been proposed to make a plantation in the sharp corners of the fields, and to round the inner fence, so that the ploughs in ploughing the headlands do not turn, but go round the field and lay the headland in one direction. These clumps of trees will add to the scenery, and in some places be a useful shelter.

Gates.

Gates are a part of the fence or boundary which is raised for the purpose of dividing land into portions that are convenient for its use, in the state of arable or pasturing applications. The judicious arrangement and proper maintenance of these boundaries form a very important department of modern agriculture; and, consequently, a value is attached to the consideration of the best materials and the fabrication that are adapted to the special purpose. The fences are stationary and fixed, and as the use of the enclosed portion of land requires the ingress and egress of the tools that cultivate and convert the produce into value, an entry is necessarily selected, which shall be opened for admission and closed for prohibition. A bar or hindrance in this entry was very early contrived, and has been long used, called a "Gate," which is formed of bars of timber fastened together, and being hung or suspended on a fixed post or pillar by means of turning appliances of iron, which join together the parts of the timber frame, the gate moves on either side of the entry, and opens the road, or it remains across the way and shuts the passage. In every case two timber posts are required: one on which the gate is hung or suspended, and another on which it shuts, and to which it is fastened to remain across the road. The entry to the field or the gateway admits only one form of gate in an oblong square, as some objects in nature are limited to certain forms and applications. But the interior parts of this square form admit a great variety of applications with which to fill the vacant space, and it is chiefly this portion of the article that constitutes the differences of which the implement is susceptible. An adherence to practical utility must be rigidly attended to, and at the same time a neatness must be produced, which denotes a similarity with other refined objects. Every article of use must bear a corresponding degree of refinement: strong without being clumsy, and neat but not gaudy, or fancifully ostentatious.

Can only be square in form.

Every field of land should be provided with at least two gateways on the opposite sides, so as to make it approachable from each side of the ground. The width of the gateway should not be below 12 feet, nor the gate itself under 9 feet in length, so as to afford a free passage to the loaded vehicles. Gateways should be placed on dry grounds, and are most convenient when opposite to the headlands of the field, at either or both ends. The carts, empty or loaded, travel to the ends of the field, and find a straight road along the headland to the gateway, and pass to the road outside the field. The gate posts of oak, or some durable timber, should not be under nine feet in length, three feet below ground, and six feet above the earth. The part under ground should have a thick butt end, and be well fixed by means of closely rammed moist clay; the hole must be filled in that manner from the bottom to the top, with the post upright in the centre, and a turf of grass laid over the surface. The utility and stability of the gate wholly depends on the secure fixation of the hanging post; if it is unable to carry the weight of the gate, or if it yields to the frequency of the opening and shutting by the traffic, the fore end will soon fall to the ground, and the implement is

Two gates to every field.

Posts to be firm.

rendered useless. Some little labour and attention is required to make secure the foundation of the gate, which is best done in the first performance, and not to require a repetition, which is never so effectual.

Gates are formed of five longitudinal bars about four inches wide and one inch thick; the wood may be larch, ash, willow or the durable firs, and dressed by the plane to receive the covering of paint. The bars are mortised at the ends into upright small square posts of hard timber, and fastened by a wooden pin. The back end post of the gate is heavier than the fore end, as it is next to the hanging post, and is fitted to receive the iron work by which the gate is suspended. The gate is best hung by crooks and thimbles of iron; the former being driven into the hanging post, and the latter being clasped on the upper and lower bars of the gate. It is best attached to the catch post by means of a small iron catch driven into the post, and a small chain attached to the hand-bar of the gate. This fastening never can be opened, except by the hand of man. Swing gates that pass to either side are ever liable to fall too deep or rise too shallow in the iron latch that is sunk in the catch post, and spring fastenings are very liable to be undone by the animals rubbing against them. The gate must be of a height sufficient to prevent any animals getting their heads over it, and pushing with their breast against the upper bar, otherwise it is quickly broken. The posts of a gate look well when they are octagonal shaped and rounded to a top. All gateways should be deeply laid with small broken stones, as animals always congregate at the gates and convert soft ground into a puddle. No better sign need be required of a good farmer than having every gate in proper order, and every gateway affording a dry and firm passage at any season of the year.

Clap gates most lasting.

High above the animal's reach.

The reader is referred to "*Designs of Gates for the Park, the Policy, and the Farm,*" by the author of this work, and to be had of the publisher, where a large variety of gates is delineated, with a strict regard to economy and the useful convenience.

CHAPTER VI.

PLANTATIONS—YOUNG AND OLD TIMBER.

A PLANTATION is formed of trees that are placed in the ground at such distances as allow room of the full growth being attained. The object is to raise timber for artificial purposes; to convert into a profitable use the barren grounds, and irregularly formed lands; to adorn the surface, beautify the landscape, and enliven the scenery, and in unpropitious climates, to afford shelter to the cultivated portions of the earth. A tree seems to have been among the earliest productions of

Woods:

nature destined for the purpose of clothing the ground with vegetation; tall, shrubby, or fruticose, the stem is seldom absent in any latitude that permits the existence of any degree of organized life. The bulk is regulated by the quality of the soil and climate, and the foliage undergoes the same modifications. In most parts of Britain, a very equable medium is established; the bulk attains a useful standard, and the growth is generally ready, and sufficiently progressive.

The rearing of timber is an object of much value to the owner of the soil, and of a very considerable interest to the national community, in relation to the vested right which is enjoyed anent the purposes to which the surface of the earth is appropriated. In arranging these distributions of use, the rule may be held as absolute, that all lands be planted with trees, which are inaccessible to the plough by reason of elevation, declivity, or other insuperable establishment of nature. And where a grassy surface on a kindly subsoil yields a grateful herbage to animals, the position of plantations must be so arranged as to afford shelter to the grounds that produce the value in pasturage. The profit of the grazing will determine if the use continues for animals, or may be better converted into a plantation. Very high elevations deny the growth of any vegetation; grasses will grow where trees cannot live, and consequently such a value must come from these situations as nature is pleased to allow. Plantations are best made on moderate elevations, on sloping grounds that deny cultivation, and on low situations where for special reasons a congregation of trees may be eligible. Use and ornament will always determine the establishment of plantations, and regulated and modified by the contingent circumstances that ever attend the purposes of active intention.

only on barren lands,

or inconvenient to cultivation.

Trees of use are naturally divided into two large assortments of hard and soft timber, the former bearing the seeds in imbricated cones, and the latter in shells, nuts, and drupes, which form coverings of a greater or less hardened consistence. At the periods of full ripeness, the seeds are gathered, and safely reserved for being sown in the proper seasons on finely prepared grounds, that are fenced round, and duly cultivated for the purpose of nursing the young vegetations. The seedling plants are moved from the bed of one year, and placed in rows, where the weeds are killed by hoeing the intervals, and only the moderate growth of the plant is encouraged. At the end of two years, the trees are ready for the use of the plantation, or to be placed in wider rows in the nursery, there to wait the demands of sale.

Young plants.

Grounds intended to be planted with trees, must be completely fenced during the year previous to the planting, and thoroughly laid dry by open drains, if the nature of the land requires the removal of water. These ditches are placed in the lowest grounds, and follow the sinuosities of the surface in every direction, however crooked or awkward the appearance may become. The general discharge must lead to a large ditch, brook, or rivulet, into which the water escapes. The conveyance must be clear and uninterrupted to the outside of the plantation, if at all possible to be

got. If a flat surface occur, an artificial level must be sought and made for the special use.

Two methods are adopted in planting trees: one way opens circular pits in the ground, three to four feet apart, about one foot deep, and one foot and a half in diameter. The tree is placed upright in the centre of the hole, with the rootlets carefully spread abroad by the hand; the excavated earth is turned into the pit, and trodden firmly round the trees by the foot, and then the grassy turf is placed as before over the pit, and cut in two parts with the tree in the incision. The earth being trodden firmly by the foot, and the turf being compressed by the back of the spade, finishes the planting of the tree. This mode is adopted for plants of the largest size, which are placed at the widest distances on the ground. The second way of planting trees, makes two incisions with the common spade, centrally crossing each other at right angles; the tree is placed in the ground at the point of intersection, the spade holding up the turf till the plant is fixed, and then depressing it to secure the position. The roots of the plant are neatly dressed by knife, and the feathers are arranged in the new position before the fixture is accomplished. This method is cheap and expeditious, and leaves the roots among the best soil on the surface of the ground, among which to spread horizontally, and establish its abode; whereas in pits, by the first way, the roots are placed in the subsoil, which is often very pernicious and inimical to vegetation; the growth is stopped, till new roots emerge from the stem, and draw subsistence from the upper soil. Trees are fibrous rooted plants, and spread horizontally along the surface of the earth; no tap root descends to require a depth of humified earths, and consequently the insertion may be more shallow, and the labour less costly. The last mentioned method is therefore the preferable way of planting young trees in the ground.

Planting of trees in pits; by incisions in the ground

The distance between the plants and the number of trees that are required to cover an acre of ground, are very much varied both in opinion and practice. Hard timber trees, as oak, ash, and elm, are usually planted at four feet apart, on the calculation that the one-half of the trees are taken out when risen to one-third of the full growth, in order to make room for the standing crop, and that these remaining trees need the space of eight feet between them. But experience has shown that a full crop of timber trees can stand in four feet apart, and consequently the first planting must be thicker on the ground. The larch and Scotch fir are found the most suitable plants on the highest exposures, and even on the sheltered slopes of these elevations, these trees maintain the greatest worth: on the lowest declivities, and upon the best grounds, the oak, ash, and elm, usurp the preference: and on low flooded lands which cannot be amended, the willow and alder will be the chosen plants. The beech on chalks, the hazel on rocky banks, and the birch on barren gravels, will be useful introductions; and in some situations, the Spanish chesnut will equal in value the most esteemed tree in Britain. In every case of planting trees on high or low grounds, and of firs or hard tim-

Trees on an acre of ground

varied by situation.

ber, the distance between the plants will be two feet, and the number on an acre will vary from eight to ten thousand. The plants of hard timber may stand at two feet and a half apart, and in certain exposures, the firs may be so close as eighteen inches. These close distances are required to create a mutual warmth, and to promote the upright shooting of the plants by preventing the lateral expansion.

Time of planting.

The planting of trees is best done in the months of November, December, and January, and during the mild fresh weather that occurs betwixt the frosts and snows of these wintry divisions of the year. So soon as the setting of the plants is accomplished, the gates are shut, and as the fencing has been previously done, the performance is wholly completed. Roads of twenty feet in width are left in the convenient directions over the planted grounds, and so arranged as to afford a ready and convenient access to the working requirements, and to the vehicles of export when the felled timber is removed. This convenience is never to be omitted being made in all cases of plantations of trees. Open ditches are to be dug along the sides of the road in all places where water may overflow the passages, and are directed to discharge the contents into some one of the main outlets. On wet lands only these drains are necessary.

Roads in woods.

Our system of close planting allows the trees to grow altogether unmolested, save the insertion during two years of fresh sets in the places where a failure of the growth is seen to happen. The most vigorous and thriving trees take the lead, and carry the pre-eminence, and strive to reach the benefit of sunshine, which is necessary to a prosperous vegetation. A certain number of plants attain that station, and form an umbrageous canopy of leaves and branches that join in the contact; beneath this covering, all vegetation is killed, and almost every life extinguished, at least that rises upwards in any considerable height. The trees that cannot rise upwards into the sunshine, are killed, and when seen to be fairly mastered, are usefully removed for fencing purposes; the lateral branches of the trees that succeed in obtaining the permanent elevation, die away, from a beginning at the bottom of the stem, and are killed progressively upwards, according as the tree rises in height. The decay follows closely on the ascent of the stem, and there is left on the top of the tree "only" a round canopy of green branches and leaves, of a small vertical extent, and so far laterally as the contiguous formations will allow. The stem of the tree becomes a straight bole without any knots or blemishes; the upward struggle of growth prevents any bendings or lateral inclinations, and the efforts of nature are directed to one chief point. By this method, nature exhibits the finest timber in the world; in the wilds of America, in the straths of Scotland, and on the Alpine cliffs of Norway, the seeds are sown by the wind, and the roots are struck into the uppermost stratum of decayed vegetable earth —a lesson which forbids the pruning or lopping of branches, and the insertion of the young plants deeply into the ground.

Thick planting

renders pruning not necessary.

The pruning of trees, or the cutting away of the branches, by a saw

or chisel, is a mangling process, which very much damages the timber of the stem. Sap flows to an incision, and very often protrudes a number of young shoots; or a struggle is made to cover the wound, which forms a large blemish when the timber is sawn for use. When the tree prunes itself by means of a killing confinement of the lower parts, as by thick planting, no such accident happens; the decay is gradual and progressive, and the sap flowing upwards by the attraction of heat, leaves the branches to a complete annihilation: there is no wound to be covered with bark, the branch drops off, and the junction with the stem is soon imperceptible: the expense of pruning is avoided, and also the labour and cost of thinning, which is seldom repaid by the value of the clearances. The trees grow to a full maturity, and have no attention, except in keeping the fences good against trespass, and in removing the stems that are undergrown, before rottenness destroys the use for fencing.

Expense avoided.

About one-fourth of the number of trees planted will remain for crop, and will average about two thousand on an acre, standing at four to six feet apart. The other portion of the original plants is sacrificed to the purpose of raising the standing crop into a prosperous condition.

The observant eye that looks into a congregation of trees which have been grown from nature's care, or that have escaped the havoc of the thinning and pruning performances, cannot fail to discover the truth of all the above statements, and that the system is also supported by the most rigid adherence to established laws. In these places are seen the stems of trees, tall and straight, without branch, knot, or excrescence of any kind, and the bark slippery and smooth without any interruptions. Wherever the sun and light are allowed to penetrate the branches of trees will seek it laterally as well as vertically, and the number of shoots will be proportioned to the free access that is given to these necessary elements of growth. The vegetation is thus directed to many points, the tree becomes a bush, and fails to reach the height of a timber provision; the stem is knotty and rifty, and worthless in the hands of the workman; and the wider standing of the trees reduces the number on an acre of ground. On low grounds which approach the residence of demesne, a luxuriant foliage may be wished, and then the trees are thinned to the distances that may be required. An undergrowth of bushes may be wished to shelter the beasts of game, when the openings betwixt the trees must be wide to admit the sun and light to nourish the evergreens that form the cover. In such cases, a distance of ten to twenty feet may intervene betwixt the trees, and the first planting may be in the half or a third of that distance, and the supernumerary quantity of plants are removed at different stages of the growth, leaving the number to stand for crop.

Quality of timber improved.

The fir tribe of trees generally reach maturity in about thirty years, and the hard timbers in forty to sixty. Fellings and sales are then made according to the wants of the locality, and the purposes that require to be supplied. In every case the trees are felled, topped, and lopped by the owner's expense, and drawn outside the plantation, and

Maturity of trees.

laid in convenient lots for sale, whence the removal is made by the purchaser. Every tree must be cut down, save some few choice standards that are left in the outside to adorn the scenery, and the empty ground is immediately filled with the suitable plants, as before directed. No trees are to be left standing in the interior of the wood; the ground must be clear, as young trees never thrive under the shade and drip of the full grown forerunners. The custom is most pernicious that mixes growing trees of different ages; the younger always suffer from the older, and the general appearance is never thriving or satisfactory. In this way the cutting and planting of trees go on in an uninterrupted succession, and the ground is never empty of production.

Sales.

Woods to be clean cut and none left.

When plantations have been neglected, and allowed to grow in old timbers, younger trees, and a bushy underwood, the evil becomes very apparent of such a mixed system. By cutting and removing the full grown trees, a very great damage is inflicted on the smaller growths of every kind, and the younger trees when put in full possession of the ground, form only the half crop which the land is able to bear. In this way the evil is perpetuated, and each succeeding generation grows to damage the following vegetable increase. The most effectual way is to cut everything completely from the ground, and to plant afresh with the suitable plants, and attending for some two or three years that the young trees that are planted be not overpowered by the thick and rapid growth of the underwood, and the shoots from the old stools which possess the vivacious principle. These exuberances are very useful in sheltering and drawing into a tall growth, the plants that are inserted in the ground, provided the density be not allowed to choke the growth of the young trees—this danger exists only for a short time, and is easily avoided.

Neglected woods to be wholly renewed.

Hard timbers and firs are best felled in the end of the year, and removed before the spring growth is commenced. The ground is planted with young trees in the same winter. Oaks being cut for barking in the early summer, the planting of the land with fresh growths is delayed to the next winter, when the process is repeated, as above described. In every case the clearing of the ground must be complete, save some few choice trees in the corners or fences of the plantation, which may adorn the scenery and enliven the landscape. The remnants must be few, and all others are indiscriminately removed.

Felling timbers, and barking oaks.

Copse or coppice is a plantation of trees that rise to a certain growth of years, when the stems are all cut and sold for the respective purposes of use. The trees are of the vivacious kinds, that send forth shoots from the old stools after the growth is cut, and the most rapid in vegetation are necessarily preferred. The whole tribe of fir trees, or the coniferous division of plants is wholly excluded, and the choice falls on the oak, ash, elm, willow, and chesnut. The fir plants are deficient in the vivacious principle, and those trees are most eligible which shoot readily from the stools and prosecute a vigorous growth.

Copse woods.

Inferior lands are generally converted into copses, as banks, rocky declivities, barren wastes, and flooded grounds. In the first formation the plants are inserted as for a timber plantation that has been already treated, and the stems are immediately cut close by the ground. Sometimes a year is deferred between the planting and cutting, but with no convincing advantage. The growths are ever more rapid and vigorous from a cut stem than in the natural stalk from the nursery. This fact is generally well understood, and the practice adopted in the case of a new copse wood being formed, and the strongest plants in the nursery are used, as they, when cut, send out the most healthy and vigorous shoots, which in the shortest time are led into the form of the useful purposes that are required. The sets are two feet apart as for timber, the near contiguity being equally required in order to induce the quick and upright vertical growth. The vegetations that are not able to attain the height of the upper reach, are dwindled into the inferior purposes, as will be afterwards detailed.

Various in the situation.

Planting.

Copse woods mostly prevail in the hop-growing districts of England, and these localities are chiefly situated on the chalk formations, where coal is not found as fuel. The hop plant requires a pole to support the twining stem, around which it climbs and fastens by means of tendrils. This purpose uses the tallest and stoutest growths of the coppice. Fuel demands for its most urgent purpose the use of all the inferior stems, branches, and bushes, or all the growths that are inapplicable to any other purpose by reason of want of strength and bulk. The intermediate growths occupy the middle purposes of stakes for fencing and for making sheep hurdles, and this use becomes in many places the principal application.

Copses generally attain the full growth of the purposes for which the articles are used in the time of ten to fourteen years, when the produce is sold by auction or private bargain in a fixed sum of money by the acre of land. The purchaser cuts the timber in every shoot or bush of any kind, applies it to his own purposes, and removes the whole articles outside the plantation by the first of May, when the young shoots from the stools will sustain damage by the trespass of any intrusion. The brushwood that grows on the earthen mound or fence belongs to the purchaser, who plashes a new fence with the thorns which he cuts for his purpose. The fence is not included in the measurement of the ground, and the purchaser gets the stems that grow upon the mound for the trouble of plashing the new fence. The growths are cut from the stems by an upward slanting cut of the axe, and the face of the cut must be clean and even, that no roughness occur to lodge wetness and lead to decay. The new shoots rise from the seam of the wood and bark, and the more sloping extent of cut will produce a greater number of fresh vegetations. But a medium is to be observed, as the stool will not support to maturity a disproportionate number of shoots. The eye of experience will easily fix the proper elevation of the cut.

Purposes of the produce.

Manufacture of the woods.

In the southern counties of England a quantity of woodlands belongs to most farms, which are cut at the proper season, and used by the farmer as

any other crops on his lands. This arrangement supplies the farmer with firewood, and also with fencing and hurdle stakes, and the demand for hop poles in his vicinity will add to the accommodation afforded by the woodlands. But it may be better policy that the landlord manages all the woods as his own care, and the farmer can buy the fuel and stakes he may want at the periodical sales of the articles. The landlord would thus employ a fixed number of special workmen under an experienced and trusty foreman, who will be employed during the year in cutting copses, felling timber, barking oak, and upholding fences. The cuttings will be duly separated into the purposes of use carried outside the plantation, whereon a fixed day the disposed lots are vended by auction, or previously sold by private treaty, and the time of removal is expressly certified. The landlord has thus the certainty of the lasting object being duly provided, and can make what alterations he pleases at any time.

Best property of them

A long continued cutting of the stools of copse wood forms a dense tuft or collection of the ends of the shoots upon the old stool, in the cavities of which the water lodges and induces decay. In these overgrown cases, the whole collection is best removed by cutting the old stem close by the ground with a saw, and slanting the cut upwards, so as to prevent a lodgment of any kind being made upon the incision. This operation presents a fresh source of shoots, and very often most wonderfully renovates the condition of the stools. When a lengthened age has wholly debilitated the production of suitable growths from the stools, it is the best way, as in the case of full grown timber trees, to dig and remove the old stumps wholly from the ground, and to plant with nursery sets, as at first, the entire area of the plantation. The sets must be placed in fresh ground, and not in the holes whence the stools are removed. This renovation is the same as making a new coppice.

Old stools to be removed.

Though it is very customary, it is still highly objectionable, to grow together the trees for timber, and the undergrowth for coppice purposes. The timber trees stand widely, and the branches spread in an extensive lateral expansion, the stem never rises to a height of bole to constitute utility, and covers a large shade, under which the copse wood does not thrive, but dwindles into an inferior growth. This is an object of daily observation, and requires to be removed by copse woods occupying the ground in the one purpose, and timber trees to have the same privilege with any underwood that may rise, being cut for use at the seemingly proper periods. This arrangement is very simple and easy, and provides each purpose separately, as they do not thrive in union, and suffer mutually by the intrusion on each other's abode.

Copses and timbers to be separate.

In the hop growing districts, and on the copse lands of the best quality, the most eligible trees are oak, ash, and Spanish chesnut. The ash is quickest in growth, but not very durable as a hop-pole, the oak rises slower but lasts longer, while the chesnut very often excels both these plants, in being more durable than the ash, and wanting the fault of the oak, in being brittle and unwooded in the upper end of the stem. On dry banks and on rocky declivities, the birch and the hazel

Best trees for copses.

form a good undergrowth of stakes and fuel, but never rise into hop-poles, for which purpose the oak, ash, and chesnut are the most valuable trees. On lands that are damp and moist, even after a complete surface draining, the alder grows well, and affords hop-poles of the first quality, and stakes for the fence and hurdles. On the lowest grounds, the willow tree yields the largest produce, and hop-poles are often obtained of the best sort. The ash obtains the widest range of growth, as it thrives well on all soils, from the flooded ground to the sandy waste; but the inferior growths of it are not equal in quantity to that of the hazel and birch, and on chalky lands the beech exceeds all others in bulk and produce, though it is chiefly adapted for fire-wood. It seldom rises to the height of good stakes. The trees now mentioned are adapted for any variety of soils that may occur, and present a selection which suit the occupation of any lands in Britain.

Varied according to soil.

No advantage attends any preparation of the ground for trees by being dug or trenched, especially on high situations; experience has shown that the growth may be superior on trenched lands for the space of five or six years, when it falls to the standard of the unprepared grounds. The sole attention in making plantations of any kind for timber or copses, is directed to complete fencing, open draining of the surface where wetness prevails, and roads of twenty feet in width traversing the grounds in the convenient directions, by which to obtain access for any purpose. The only work to be done till the timber is full grown is to remove occasionally the trees that are smothered by the taller growths, and use the stems for some purpose before the decay performs a total uselessness. No pruning or thinning is to be done in copse woods, as the thick growth is necessary to promote the tall and straight form of the poles and stakes, which would spread laterally into branches if room was given for that purpose. The full growth is reached in ten to fourteen years; and the value of copses varies from £8 to £20 per acre, according to the quantity and quality of the produce, and the price of the different articles in the locality. In many places, the poorer lands of all sorts pay as much rent as the cultivated grounds, where the small necessary attention is bestowed. Many wastes in the districts wanting coal might be well used in copse woods, and especially rocky declivities, on which no other improvement ever can be done. The first expense is comparatively small, and though the times of payment are far between, the return is more certain than yearly crops of vegetables, and the casualties are much less numerous. The yearly cost is something, and is covered by a very small produce and a low price.

Digging of land not necessary.

Copses not pruned.

Value of the woods.

Seeds of trees that fall to the ground germinate and strike roots into the soil, from which timber arises that is better in quality than the trees that grow from the plants of the nursery. This fact is well known in every timber growing quarter of the known world. When the timber is used by the saw and chisel of the workman, the operator can tell if the materials had grown from the seed or the plant, the former being cleanest in the fibre, and presenting a smoother surface from the action of the tools. It

Timber best from seeds. follows that the seeds of trees be thickly scattered on the land which is to be planted and allowed to germinate and strike roots into the ground as in nature's way. The seeds are mixed in a large variety, so that success be the more certain, and sown by hand in at least four bushels on an acre. It will be advantageous that the grass on the surface be not consumed by any animals for some years before the seeds are sown, but allowed to fall and decay yearly, which will afford a bed of vegetable earth for the germination of the seeds and attaching of the roots to the ground. The young plants will grow in a thick condition as from the inserted stems; the thriving individuals will rise and form the crop; and the inferior growths will dwindle into underwood, or be altogether extirpated. The quantity of seeds must be very ample, and when a failure is observed in the first and second years, another sowing must be done in a smaller quantity, and every means used to obtain a full crop on the ground. All vermin that eat tender shoots and gnaw the barks of trees must not be present; and the fencing of the sown grounds must be very secure. The collection of seeds for use will supersede the nursery, and a very considerable expense will be saved. Nature has shown the way; and the results are superior to the mode that is now followed, which employs much more time, and expends a larger cost. The stem of the nursery being cut close by the ground when the tree is planted, sends forth a vigorous shoot, which grows far more luxuriantly than the old stem; and this shows the superiority of every growth from the position where the vegetation is to be permanent, and the seed is more vivacious than any stem.

To be sown on the ground.

The above detailed system of very thick planting, which promotes an upright straightness of growth, and kills the under-branches without the mangling of the pruning process, is founded on nature in the first place, and has been illustrated by the practice of the Duke of Portland on his extensive landed estates, in the counties of Nottingham and Northumberland, and in Ayrshire, in the west of Scotland. His Grace is known as the originator of several most correct practical maxims on various agricultural subjects, which are introduced and practised with a most extensive benefit, and are never disturbed by any of the evanescent theories of the day. Our opinion has ever admired the planting of trees, as now detailed, and for which an appeal is made to his authority; the system has an unerring law of nature for its base, and reason for its guide. On the subject of planting acorns and placing young trees, his Grace writes in a private letter on the matter:—"Fine large acorns produce very superior plants for some years; but I do not think I have seen that superiority disappear till after the expiration of more than seven years.

Duke of Portland; his authority

Communication.

"I am quite satisfied that the effect of double trenching is to operate a permanent benefit. I did not see this effect in a plantation till it was twenty years old. It was by mere accident I discovered that effect; but I have since acted upon it extensively, and subsequent experience has confirmed the truth of the appearances. The roots of the plants work more

easily, get sooner out of reach of the effects of the sun, and the rain sinking deeper into the earth, is not so soon evaporated."

In the matters of planting and draining, our work has adopted his Grace's practice, as the most just in principle, and efficacious in the result.

CHAPTER VII.

MEADOWS AND EMBANKMENTS, BEDS OF RIVERS, WATER COURSES, AND FLOODED GROUNDS.

Lands that are low in position and flat on the surface are exposed to floods of water, which usurp the dominion of the ground, and damage the productive quality of the soil, owing to the time of the possession by the watery element. This damage equally ensues, whether the ground be in an arable condition or used in a state of grass, for the starvation of the land by the water, produces a low state of temperature in the soil, which continues for some time, and very much retards vegetation. These grounds are mostly grazed by animals, during the periods when the inundations of water are absent; but in many cases, the arable condition would be very profitable, if the presence of the water could be averted. The low position of the inundated grounds, presents a formidable barrier to the removal of the water, as the descent induces a sluggish motion, and retards the escape after the liquid has been directed into a proper channel. This obstacle has exerted much influence on the operations of embanking, and has very much perplexed the arrangements for the purpose. Where the fall of the ground affords a quick descent of the water, the process is comparatively very easy, as it only remains to provide a channel and turn the water into it. In other cases, the channels are over-charged and burst by the bulk of water, or are always full, and throw back the water into the smaller outlets.

Meadows, or low grounds.

Embanking.

Embanking may be justly termed the first branch of engineering that has been practised by the human race. Observation soon showed to the eye, that low grounds were the most fertile that were situated along the sea shore, and on the banks of rivers, and that the quality was damaged by the inundations of water on the surface, and that the area was gradually lessened by the invasion of rivers, seas, and lakes. Measures were not long in being used, for the purpose of averting the damage; and the monuments yet remain over all the countries of the ancient world, where arts and sciences were brought into life, and cradled into use. The alluvial shores, wide plains, and fertile deltas, are found to be protected against waste and temporary damage, and the confined water is directed in small channels for the purpose of conferring

The first engineering;

the benefits of irrigation on the grounds that are secured from the ravages of nature. Every country of modern Europe exhibits the marks of this ancient art—the dikes of Holland, are marvels of human industry —and the embankment of the river Po in Italy shows a skill and application of the practice that excites universal admiration. In the former country, the ocean, inland seas, and rivers, are prevented and confined within proper limits: the sediment of mud that is carried by the rapid torrents from the higher grounds, sinks in the channel of the rivers and raises the course of the water above the surrounding level, where the inhabitants have their homes, and cultivate the grounds. A rupture of these banks would inundate a whole region of country, devastate the property, and probably drown many thousands of people: yet such is the feeling of security produced by the skill and labour of centuries, in devising and repairing these artificial mounds, that no dread is ever expressed, and a bank of mud is felt sufficient to repel the floods of rivers and the storms of the ocean. The river Po rushes impetuously from high grounds into the valley of Lombardy, and runs during the half of its course of 300 miles into the Adriatic sea, over a country of alluvial flat, where the descent is small, and the course is slow and sluggish; the bulk of the water is much swollen by the dissolved snows of the Alps, and the torrents carry along vast quantities of fine earth that is torn from the high grounds which, on reaching the low country where the water moves slowly, or almost stagnates, sinks to the bottom as sediment, consolidates, and elevates the bed of the river. This natural course of centuries has raised the channel of the water above the surrounding country, and embankments were raised at an early age in order to guard the labours of man from the ravages of the unloosened waters. These banks are models of skill and industry—of ingenuity in the plan, and of perseverance in the maintaining of the bulwarks.

in Holland; in Italy; with the river Po;

In Britain, the embanking of grounds exposed to damage and degradation, seems to have been begun at an early period of time, though probably not before the Roman conquest. The Romney marsh and the flat grounds of the estuary of the Thames, may have been the work of the Romans, who had attained much knowledge of the art, and were ever ready to communicate their acquirements to the victims of their conquering policy. After the retreat of these improving adventurers, the art of embanking slept in the general slumber of the human mind for the dark period of one thousand years, and revived in the sixteenth century, along with the universal resurrection of arts and sciences, men and manners: foreign intercourse showed the policy of Holland, which country sent engineers to Britain, who commenced with the draining and embanking of the fens of Lincolnshire, where the sea comes far inland by reason of the flatness of the alluvial formation of the country, and the descending rivers are prevented the discharge of the waters into the sea which are consequently thrown back upon the surface of the ground. Two centuries of repeated attempts have scarcely sufficed to complete the emancipation

in Britain.

of these overflowed districts; but the operations have very much conduced to advance the skill of the art of embanking, and have shown the principles in many different forms.

Three uses of embanking;

There are three applications of the use of embankments, in guarding the encroachments of the sea, in turning away occasional floods of water from the surface of flat lands, and in preventing the waste of alluvial lands by the invasion of rapid streams or torrents that tear, waste, and carry away the soft and unresisting earthy accumulation of tender ingredients. The shores of the sea are most generally either rocky or sandy, which are useless for cultivable purposes of any kind, and the cases are not many where the ocean intrudes on grounds that are worth any cost and labour in the defence. There are some few instances of such an occurrence, but the greater part happens in the case of inland seas or estuaries that penetrate the country, and on the sides of which the alluvial flats have been formed that require to be protected. In these situations, the force of the sea is much less than of the open ocean—the tides rise gently, and the winds have a very diminished effect. The tides are not impelled by furious winds blowing in the same direction, and the mixture of fresh water very much lessens the power of the briny liquid. But the barriers to be opposed are the same in both cases, as the resistances come forward in the same manner, and are formed of similar elements.

rare with the Ocean.

Embanking is based upon very simple principles, but the application of them to practice requires both skill and experience. The fundamental principle is, that a liquid presses upon any resisting solid, not by any dimensions, or general properties of the fluid, but solely with a force proportionate to its depth. Hence when a perpendicular bank is opposed to a body of water, it has to sustain the pressure of the depth of the body, and undiminished by any assistance that can be given at it. This is a fixed law of fluids, and carries along with it the simplest conviction of practice. It only remains to convert the deep pressure laterally into a shallow depth vertically, and thus reduce the opposition from an impinging force into a rolling harmlessness of motion. On this principle, soft materials being hardened into a body, are equally useful with the hardest rocks, or even walls of cemented masonry; and have the surface so levelled and crusted, as that the ripple of the rolling water does not make a breach, or form any beginning of damage. Banks are made with compacted earth, in the dimensions of three feet of base to one of perpendicular height. The slope is set to the sea, and covered with turf, the pieces of which are fastened to the surface by means of hooked wooden pegs. This growth of grassy surface presents the best of all materials on which waters roll without doing damage, and it is fed by the alternate benefits of being dry and having a watery covering. The mound may be six or eight feet wide on the top, and have a slope to the land of one and a half feet of base to one of height, or about one-half of the seaward slope; the whole construction being quickly and carefully covered with turf, and being duly attended and repaired, will

General principles.

Best materials.

very soon become a grassy barrier of much strength, which will bear an intrusion beyond its appearance.

Slope of banks.

It is a law both of theory and of experience that the greater slope of a bank, the more effectually it performs the object of its purpose, and its end as a resisting surface. There is no precise rule for the degree of slope, because it depends on the nature of the materials of the bank, and on the degree of exposure to the winds, waves, and currents of the tide; but it should rather be above than below the average now stated, of three feet of base to one of height, and in no case below two to one, even where the resistance appears to be very much reduced in force. The height must be above the highest known rise of waters, which must not wash over the top of the bank, and the slope height may be six feet above the water line. Much care is required in forming the slope of the bank to the sea, in order to prevent any breach, or abrasion of the surface; the earth is beaten hard with mallets, and the grassy turf is best taken from the sea shore, when the plants will be proper to the maritime situation, and may be chiefly the sea carex, the upright sea lyme grass, the sea rushy wheat grass, and certain kinds of the sedge. The creeping roots of the plants extend beneath the surface, bind the loose earth of the bank, so as to enable it to resist the continued action of the waves. A thin coating of straw, and sometimes fascines of osiers, or branches of any kind

How secured.

are pinned down on the bank to form a kind of thatch; but the simple turf, when laid with care on a well prepared bank, is the most sufficient.

Where banks are exposed to high rolling tides that are driven in fury by storms of straight in-blowing winds, the necessity occurs of driving into the ground two rows of piles in three or four yards between, and filling the empty space with the largest stones that can be found. This front barrier being placed in twenty feet distant from the grassy bank, will act as a breakwater; the fury of the waves is broken by it, the water passes through the loose mass of stones, gathers in a placid body between the barrier and the bank, and rolls upon the latter like a standing pool that is gently moved by a force that is distant and little troublesome. Where stones are scarce and wood abounds, the piles may be driven into the ground

Front protection:

almost close together, when the quantity of them will constitute the barrier, but stones are preferable where found within a reasonable distance. The bottom of the grassy bank will be in no danger of being undermined from the quiet re-assemblage of broken waters as by the furious lashings and peltings of the merciless beat of briny waves that search every access, and explore every crevice. To prevent the very smallest entrance into the bank being obtained, in case of there being no breakwater erected, the bottom of the bank in the grassy turf, must underlie the slimy ground of the shore, and the hardened mud on which the water rolls must overlap the turf of the base of the mound, and conduct the roll of the water from its own slope to the grassy bank without any obstacle intervening at the junction of the mound with the shore. If the water beats against any resistance, it will soon make its way, and an entry

once found will quickly lead to an overwhelming destruction. The whole secret lies in making water always roll upon the resistance, but never to impinge against it. Where streams of water from the country must pass through the bank into the sea, a suitable opening must be left in the mound, and built with solid masonry, of the size to permit the free egress of the largest quantity of water ever known to demand admittance; when the tide is ebb, the discharge is free and easy through this opening of the fresh water from the land; and when the tide rises, it will, if unrestrained, pass through the orifice and inundate the flat lands which the bank was erected to defend. To prevent this intrusion, a gate of thick boards strengthened with iron bars, is suspended by hinges to shut the opening as closely as the wood and stone wall can be fitted to join. The running water from the country pushes the gate before it, and keeps it open, and runs freely into the sea—when the tide rises, a heavier force of water rolling against the gate shuts it, by which the sea water is excluded, and the fresh water from the land is confined inside the bank till the tide recedes, when the gate is opened by its superior weight against the receding tide, and the congregated waters escape through the opening. This arrangement provides a bed inside the barrier in which the assemblage of fresh water rests without doing harm during the presence of the tide outside; but, except during very heavy land floods, the quantity will be vastly inferior to the tides that were formerly admitted, and therefore much surface will be secured from overflowing. This simple mechanism is applied to one river flowing into another as well as running into the sea; the inferior stream is overpowered by the greater pressure of the main river, but being collected inside a mound, and a gate being provided, it will open the sluice when it equals in weight the quantity of water outside, and flow away. But the waiting congregation of waters is often inconvenient.

openings in banks:

gates or sluices:

open and shut with the tide.

A more costly, but a generally more effectual mode, consists in leaving no opening in the bank; but collecting the inside waters, and erecting a steam pump, by the constant working of which the river is hoisted over the barrier in continued discharges. This mode is essential in cases where the country is below the level of the sea, as is frequent in Holland and in the fenny districts of England. The steam is superior to the windmill, or to any power yet known, by reason of the steadiness and constancy with which it acts: and the pump is preferable to wheels and buckets, in being less cumbersome, easier managed, and less liable to accident.

Pumps.

When the raising of an embankment occurs on ground that is covered by every tide that flows, the difficulty is very perplexing in securing the works as it proceeds, against the tides, and also against the storms and gales that may occur. The near completion of the work is frequently thrown back to a beginning by some slight breach, which leads to an overthrow of the whole structure. Practical skill and resources are imperatively necessary in the chief operator who directs the works, and caution and foresight are nowhere more in request. The most secure

way is to make a temporary fence by means of piles and stones in front of the mound being erected, which will break the storms, and guard from damage the erection till the work be completed, when the protection may be removed. The dam, if not wholly close, will at least turn away the chief parts of the water. Such a guard is almost indispensable where the water is a regular attendant.

These descriptions guard against the overflowings of land by tidal estuaries, that are often augmented by fresh water floods of the streams or rivers that flow into the arms of the sea. The flatness of the alluvial valley permits the ascent of the tide, and the lateral low surface of the ground allows the spreading of the commingled waters. Where the tide of the sea cannot rise the ascent of the country, the alluvial valleys still remain very flat, and the rivers that flow through them are slow and sluggish in the course, and when swollen by heavy falls of rain, or by melted snows, the adjacent meadows are overflowed by the excess of water, and damaged by the cold application. The protection of these grounds from damage, occupies the next attention.

Alluvial valleys.

Rivers are the great natural channels for conveying the surplus waters of the globe to the ocean, which is the general receptacle. The hollows and sinuosities of the earth generally regulate their course, depth, and width of channel, and are all dependent upon physical laws, which are as usual seen to be connected with a purpose or design. The channels are variously excavated: when it is wide, the velocity of the water is reduced; when contracted, the water runs faster, and the depth increases; the current is retarded by a tortuous channel, and quickened by a straight course: when the water undermines a bank, it is only hewing out a more suitable channel, and the tide is sought to be shut out by a bar of mud being thrown across the mouth of the outlet. These adaptations are termed the regimen by engineers, and so far from being the result of chance, is dependent upon laws that permit the usual investigation. When these operations of the river interfere with the works of man, reason instructs him to facilitate the natural operations, or present obstacles to their accomplishment as shall suit his own purposes.

Beds of rivers.

A trough is the natural channel of a river, and the deviations from this form are occasioned by steep banks, a barrier of rocks, or greater or less resistance of the surface strata, when the stream of water is diverted into pools, shallows, and eddies, and excavation of the banks. The solidity and permanence of the banks depend in part on the inclination of the surface, the hardness, tenacity, and smoothness of the materials, and on the degree of parallelism that is preserved between the course of the bank and the impinging current. Tortuous courses of bodies of water present an angle of resistance to the moving fluid, which being enlarged in volume acts with violence against an earthy accumulation, tears the mass, and carries away the dissolved materials. The flat soils of alluvial formation are gradually wasted and reduced in the superficial area by these invasions of watery bodies, and the protection of the cultivated lands becomes a business of constant attention. In waters of any

Tortuous courses.

considerable depth, the most efficient protection of the banks, is made by driving one or more rows of strong and lengthy poles deeply into the bottom of the river, at the distance of about eight or ten feet from the bank, and filling the intervening space with very large stones. The row of piles must be placed in a direction of presenting to the moving waters as sharp an angle of contact as can be obtained, as this provision very much relieves the pressure, and throws off the impending weight. In the absence of large stones, baskets of strong osiers are filled with small stones and sunk in the bed of the vacant space behind the piles, and in other cases, bundles of brushwood are placed behind the piles, and held in the position by ligaments of some kind being fastened around the stakes: in this position, the sediment lodges among the twigs, and consolidates into an earthy bank. The large piles of wood by which the whole provision is sustained, must be used in quantities as may appear to be necessary from the materials that can be obtained. The weight of large stones very soon finds a bed of repose—it only remains to have two rows of piles fronting the river, which will prevent the rolling of the stones into the deep trough of the channel—small stones will require the front piles to be thickly planted, and also cross rows at no great distances extending to the bank. The placing of the piles must be thicker for brushwood, the bundles of which are pressed and held down by planks that are joined to the driven piles. A very effectual defence is erected by forming a slope bank of stones and planks, extending from the top of the bank of the river forwards to the bottom of the water, of which the surface is lozenged with cross and longitudinal planks of timber. The water rolls upon this sloping surface, as upon the grassy banks that have been described, and though it be costly, it forms the most complete barrier that can be furnished. But in the most cases, the rows of piles, with some hard or consolidating materials, placed behind, will be adopted.

Defence of banks.

Various modes.

When waters run in a straight course, little or no damage is done to the banks which confine the current: but when the bed is narrow and the line crooked, the water is broken or displaced in the particles, and the agitation that is produced carries forward violence and destruction to all opposing obstacles. The course of rivers must be straight, or as nearly so as possible, and all attempts to alter or improve the line of currents must approach to that design. All bends of rivers must be assimilated to the straight line by using the largest circular sweep that can be got, and the barriers that are presented to an impinging current, must not offer a right-angled resistance, but receive the force in a sharp divergence, and throw off the brunt of the violence. This adoption forms an approach to the straight line, and though not straight itself, it throws the water into straight course till it meets a similar obstacle, when it is similarly treated. In making new courses for water, or in improving old ones, it is a grand blunder to confine the current; water spread abroad is very harmless, and damage arises from large collections that are confined in the movement and agitated in the course. A tendency must ever be manifested to widen rather than contract the beds of

Straight and circular courses.

Beds must be widened.

rivers, and to straighten the lines of course whenever a bare possibility exists. Necks of land may be often cut through with advantage in order to obtain a straight course, even at a present sacrifice of value in the land that may be used: the gradual damages of future waste will reach the amount and exceed the present expenditure.

The notice now made provides against the damage done by the force of currents of water rushing against the banks of soft earths that are unable to resist the pressure; an injury is also sustained by meadow lands being occasionally flooded by swollen rivers, which overflow the banks and stagnate the waters on the adjoining grounds. Summer floods will often come during hay harvest and sweep away the cocked and tedded hays, or mix with sands and mud the unmown herbage, and render it useless for any purpose. These floods being spread abroad are not violent in the action or large in force; the intrusion is easily averted, and the direction controlled. A bank is raised of the materials of the ground on the perpendicular height of three feet, which will overtop the highest flood that may occur. The base will extend ten feet towards the river, which will afford a very gradual slope of vertical height. The mound may be almost perpendicular on the field side, as the bank has not to sustain a force pressing directly upon it, as in the case of the tides of the sea that rise with a constant appointment; it lies in the direction of the current of the river, and has only to support the weight of a fluid body that glides along its exterior, but does not exert an action upon its constructed strength. It has only to show the course to the water, and not to impede or obstruct it; the outspread water is restrained, but not denied any prescribed course. The bank must recede some little distance from the bank of the river, and be so directed along its course as to avoid any abrupt turning or hollows where the waters can lodge and press with weight; the exterior slope must be convex, and the line must be uniformly gradual in the bendings, and afford the water an easy rolling motion, without any ripple or displacement of the particles. The bank is constructed of hard rammed earths, that are covered with grassy turfs, and may be one yard in width on the top. Care must be used that the embankment is continued to the first current of the overflowing, in order that the water does not get behind the mound and render it of little avail.

Flooded grounds.

Mounds.

In alluvial countries, as now described, the grounds are flat, and the currents of water are slow, and hence the means of prevention of harm are adapted to these qualities. Rivers of greater or less magnitude, that flow from hilly countries, are rapid in the course from the fall of the ground, and liable to very sudden risings of water, by reason of heavy rains in the mountains: the impetuous course continues till the flat country is reached, and before that period, much damage is done by the raging waters rolling against the banks, tearing away the loose soil in the narrow alluvial valleys through which the river flows, which very often amounts to a total alteration of the course, when a bed of gravel is left for the new bed that is taken from the cultivated lands. These hilly grounds and narrow valleys produce more bendings

Hilly lands.

Much wasted

than happen in wide plains, and the soil being mostly of gravelly loam, the waste is easy, and the demolition very quick. The gravel which is carried along by the torrent is usually heaved against one side of the channel, which being obstructed, the water is driven to the other side, and with the whole force and weight it undermines and tears the soft alluvium of which the flat lands are formed. The power of the water is most prodigiously augmented by the narrow channels which are formed between the natural banks and the mounds of rolled gravel which shifts with the floods and lies where deposited.

The furious rush of these impetuous torrents requires to be opposed by the strong erection of very hard materials. Solid stone work is the best resistance, built of squared blocks, with or without mortar, and raised to a height beyond the highest rise of the waters. The form of the bulwark is square, and longer in the face to the river than in the breadth to the land, and must be very firmly based on the solid substratum that is reached by digging through the alluvial mass of gravels and loose earths. The barrier is called a jetty, and is placed to receive the current of the water at a sharp angle of divergence, and to throw it off easily, and almost without seeming to stop the direction of the stream. An obtuse angle of divergence will throw the force of the water against the opposite bank; and if the bed of the stream be narrow, the water will break it, and probably cause a damage equal to that which is sought to be prevented. The jetty must throw the current of water into a mid-channel, and not against either bank; and consequently, the face of the stone work must be in a straight line with the mid-channel, into which the water is wished to be directed. The force of the current being broken against the jetty, the water will require to flow for a considerable distance ere a new force is acquired, unless the fall of the country be very great; and when a fresh current is formed which threatens danger to the bank, a jetty is there built, which turns the stream as before into mid-channel and clear of either bank. In this way the stream is conducted from jetty to jetty in a harmless torrent till it reaches the placid flow of the level country, when it is directed by the embankments of the former description.

Stone jetties

to break the current.

It is useful to protect jetties in front where the streams are very powerful, by placing large stones in a loose position at the base of the wall, and raised to the height of the ordinary quantity of water. The bottom of the heap may extend to three or four yards into the stream, and taper to one stone at the top where the loose aggregation leans against the jetty. The weight of each single block must be sufficient to secure for itself an immoveable bed, and defy the force of the water to change the position. In the substratums of clay and alluvial earths, strong and lengthy wooden piles may be driven into the bed of the stream, as has been mentioned before, and a defence formed between them and the jetty; but in many substrata the driving of piles is difficult, and the loose aggregation of stones will be preferred. Both ends of the jetty must taper backwards into the bank with a wall like itself, in order to prevent at the

Piles of timber.

upper end the ingress of water behind the building, and at the under end the eddying of the stream into a corner, which may become the receptacle of waters that may seek a new channel. The whole volume of the stream must be directed into a mid-channel, and without any scattering of the sheet of water towards either of the banks. The collected stream will wear a channel for itself by the weight of its volume, and for that purpose every encouragement must be given to direct it in a mass. This direction is very peculiarly applicable to streams that descend an alluvial valley from higher grounds, where the banks are in composition soft and easy of demolition, and where the rapidity of the torrent soon excavates a bed for the water. It is not here meant to confine the bed of any river of water, but in certain cases to direct the body of water in a mid-channel, which will keep it from running against the banks and tearing away the land.

Mid-channel to be always kept.

Watercourses are beds of rivers on a small scale, that traverse estates, farms, and plantations, on their way to join the main rivers that lead to the ocean. A surface of undulations and sinuosities very often compels a tortuous course of the waters, and a formation of gravel or of soft alluvium of ground gives way to the floods and torrents that run in the bended course that has been excavated. These torrents are chiefly from floods of rain and the melting of snows, and are confined from doing harm at the bendings of the course by driving into the ground with heavy mallets a row or two of strong stakes in one to two feet distant, and weaving a fence with the branches of trees in the manner of a basket. The space between the row of stakes and the bank is filled with the largest stones that can be found, among which the water passes and deposits a sediment, which in time fills the crevices, and the mass becomes a solid. The wicker work having the tail of the branches in the direction of the current, directs the water very quickly and smoothly along the wattled fence, and the wall being open to the passage of the water through it, no solid resistance is offered to the current, but rather a breakwater, which directs but does not obstruct the course. Small rivulets that are only periodical streams of any size, are fenced in this way by upright walls of wicker work backed with stones; and larger brooks are guarded with a sloped wall, as has been before described. This slope is well formed with strong stakes driven into the ground, the vacuities being filled with stones from the shingly bed of the stream, and the top covered with long branches of trees, with the tails pointing with the current, and fastened to the stakes by the natural hooks of the branches, or by ligaments, or by cross beams nailed to the stakes. Heavy stones being laid upon the top will add much to the solidity of the structure. In the course of time, the proper grasses will grow and form a matted turf, along which the floods of water will run with much ease and tranquillity. Very good walls are formed in this way; the materials are generally ready, the performance requires little skill and the expense is not great.

Watercourses guarded, and rivulets.

The principles of embanking are few and very simple, and admit an easy application. Water should run in a course as straight as can be obtained, and have a wide channel rather than a narrow bed. The bendings of rivers are guarded by barriers of piles and stones, and the impetuous currents of mountain streams are diverted into a mid-channel by jetties of stone masonry, against which the water rushes at a very sharp angle of divergence. The risings of tides and floods into deep formations of water are averted from doing harm by means of earthen mounds covered with grassy turf, on which the waters roll, but against which they do not impinge and press with the weight of their depth. This last principle forms the chief remembrance of embanking. The difficulties of execution will be proportionate with the circumstances of the locality, in position, materials, and labour.

Simple principles of embanking.

Irrigated grounds constitute a very beneficial adaptation of lands that are situated to undergo the special application. In dry hot countries the artificial supply of moisture was early adopted as a mode of increasing the fruits of the ground, and the practice has been in some degree continued in many countries in which circumstances permitted the use. The Romans used water extensively both on arable and grass lands, and from them the application has descended to the present day. In Britain, irrigation attracted much notice within the last hundred years; and there was scarcely left a brook, rill, or stream that was not converted to that purpose wherever it could possibly be used.

Irrigated ground.

The advantages consist in raising an early grass in the spring, in growing a large crop of hay, and in producing an abundant lattermath for the grazing of animals. In some places these advantages are very great, and compensate the heavy expenses of formation and upholding. The full benefit of flooding suppose a dry hot climate, and an easy command of water, and a position of the lands to admit the ingress and egress of the water, and an application at a moderate expense. These indispensable requisites will show that, comparatively speaking, few situations admit that mode of improvement.

Great advantages.

Irrigated lands are divided into two kinds—catch and flow meadows: the former lying on a declivity, and catching the water in its descent from the higher grounds; and the latter raised artificially, to allow the water to flow over them. In catch work, the water is conducted by a level course to the higher part of the ground, and divided into rills, which are stopped at intervals to make the water flow with a rippling motion over the surface, for which purpose all inequalities must be levelled, and the stops duly regulated, in order to throw an equal quantity over the whole space. If the declivity be considerable, the rills must be cut in a diagonal direction to follow the fall of the ground, so as to convey the water most regularly, and with a uniform motion, and in an equal quantity over the surface; if the ground be more flat and even, straight and parallel cuts will answer the purpose. When the water has passed over the whole space, it is conveyed away in an open ditch into a brook

Catch meadows.

or river; or if the ground admits, it may irrigate another division of catch or flow meadow before it be finally lost.

Flow meadows. In flow meadows, the land is generally flat or nearly so, and must be raised into ridges of ten to fifteen yards in width, with open drains between them, and rills cut along the top of the ridges, with a longitudinal fall to cause the water to flow along them, and with a declination of the sides of the ridges to the catch drains sufficient to make the water run briskly over the surface. The main or conducting drain passes along the head or upper end of the flow work, and discharges a quantity of water into the rills along the tops of the ridges, regulated by the volume they can contain, and which is thrown by the artificial stops in the rills evenly and regularly over the sides of the ridges. It passes into the catch drains, which convey it into an open ditch, brook, or river, where it is carried away. The expense of forming watered meadows has been stated at £5 to £20 and upwards per acre; the latter kind being much more expensive than the former, which in many situations can be done at a moderate cost. The annual expense has been stated at £6 an acre, and the produce at £9; leaving a profit of £3 an acre, after paying £2 10s. for rent, included in the expenses.

Expense.

Returns.

In the general management of irrigated lands, the water is admitted in November, after the surface has been eaten very bare, and the gates, sluices, drains, and rills have all been put into working order. Practice varies in the time the land is allowed to be under water during the winter months; some allowing ten to fourteen days; others, two, three, or four weeks; gradually lessening the time to a few days till the beginning of March. A month's watering may be given in November and December, with some days between each time, and in January and February for a week at a time, and latterly for four or five days. The lands should be laid as dry as possible between the waterings, and it has been much recommended to avoid raising a white scum by too much watering, and to turn off the water instantly, as damage ensues from a noxious quality in the scum, and the risk of the meadow being exposed to frost in that state. But many experienced irrigators never found any damage from that cause. In the beginning of March, there is generally sufficient grass to admit sheep to feed, and the meadow will be allowed a time to dry and consolidate before the admission of any stock. It is customary to fold the flocks on adjoining arable lands, and to graze the meadows from ten o'clock to five, when the dews will be off the grass. The herbage may be eaten close till the first of May, when the water is admitted for a few days, and again laid dry for hay. After the crop is removed, dairy cows and young cattle are admitted to graze till October, as summer watering has long been supposed to rot the sheep. The second crop of hay has been cut, but it is generally weak and flaccid in quality; and even the first crop, if not cut quickly in the season, often becomes coarse and unpalatable.

Seasons of watering.

Use of the herbage.

Irrigation is a very beneficial way of using land in places that suit the

application, and where water can be led to the grounds, and the surface of the land made uniformly level at a reasonable expense. The chief benefits attend a dry soil and a warm climate, though advantages are not wanting in cold latitudes and under watery climes. The fertilization that is imparted arises principally from the protection of the ground during winter from colds and frosts, and to the higher temperature which the ground obtains. Anlysis of soft and hard waters gave no result on which to found a preference, and no difference could be observed between the clear water of the spring and the sedimentary liquids of a still water brook. No doubt thirsty lands under a dry climate will imbibe very beneficial moisture from the waters that run over the surface, but which must not stagnate upon the ground so as to cause starvation and excess; the movement must be constant and uniform, and neither loitering nor meandering. The use of irrigation on cold lands and under stormy climates produced an overgrowth of rushes and aquatic herbs; the practice retrograded, and is now confined to the select localities, where the proper eligibilities are found. The stream of water must be constant and abundant, capable of being commodiously applied, and also having a ready escape from the grounds after the purpose has been effected. All these provisions will be examined and ascertained before an irrigation is attempted. The soil and its capabilities must be duly accounted: if it be strong in nature and will be grateful of a higher temperature, or thirsty and will be benefited by a large application of moisture. The probable expense will be also estimated, and the expected result will be placed in opposition. It is not a general use of the land, as so many attendances are required to be present. When these requisites abound, the use of water has very largely repaid the application.

Various results.

General capabilities.

CHAPTER VIII.

LAND DRAINING, OPEN AND COVERED,—PLAN, EXECUTION AND ARRANGEMENT BETWEEN LANDLORD AND TENANT.

It was very early observed by the cultivators of the earth, that moisture formed one of the essential elements of vegetation, and another observation was not much longer in being made, that an excess of it produced the opposite effect, retarded vegetation, and ultimately caused sterility and barrenness. In the early ages of agriculture, little or no attention was paid to the remedy of this damage which the land sustained: but as population increased, the wants to be supplied became more urgent, and application was made to remove the cause of this damage among the other operations of improvement. The first at-

Draining of lands.

tention was directed to the removal of springs, which are formed by outbursts of water from the under strata of the earth, forced upwards by pressure from a higher quarter. It is found that water flows in the permeable strata of the earth, as sands and gravels, and as these strata lie irregularly, unevenly, and interruptedly, the water finds or forces outlets upwards, as it is stopped in its course by impervious substances, and impelled by the pressure of its own body from a more elevated quarter. Attention was early directed to the interception of these outlets, and convenience suggested the mode of making trenches in the ground, and thus conveying away the water underneath the operations that were acted upon the surface. In order to afford a current room for the water, stones were used to make a small square culvert in the bottom of the trench, and over it was laid a quantity of smaller stones which were covered by a turf and earth, and this operation finished the process. In places where stones were not abundant, or could not be found at all, other materials have been used for being laid in the bottom of the trench, to afford a vacuum in which the water may flow, as stubble, straw twisted into ropes, and brushwood; and when the latter substance is put into neat bundles, and firmly tied together, and well trodden into the trench, which is sloped in the sides and narrowed downwards, drains have been found to run very well for many years, when filled with that material: but stones are in every case preferable, being the strongest material, and the most durable. Very many and most valuable improvements were made by this process; springs were intercepted and diverted; bogs and quagmires were rendered firm ground. Much waste land was reclaimed which was previously rendered nearly useless by the repeated interruptions caused by watery outlets. The observation of these causes and remedies was afterwards extended to the damage inflicted on land by atmospheric wetness, from the clayey nature of the land retaining too long the moisture that falls from the heavens, and thereby retarding the operations of cultivation, and lessening the quantity and quality of the vegetable productions. It was early known that clay is not permeable to water, and consequently water will not flow into the trenches but from a short distance on either side of them, on the very wet and tenacious clay lands which abound in this kingdom. On this principle is founded the modern system of frequent draining, in which the drains are placed at short distances from each other in order that the water may flow into some one of them and not remain on the land. The wetness caused by the rains from the heavens has been too often attributed to springs from below; an insufficient number of drains has been made in order to divert them: the cause lay in a different quarter, and the land remained wet as before. The knowledge of the true cause of wetness has crept very slowly into the agricultural world; in many instances it is yet unknown, and very far from being generally acted upon. The very general desire of doing things with little trouble, and at little cost, has added much to the belief of water rising from below the ground being the cause of wetness; a few drains were reckoned sufficient, which gave little trouble to the mind or to

First conceptions.

Stones for filling the trenches.

Frequent drainage.

the purse. A better knowledge is now being obtained, but not rejecting the former where found to be prevalent and necessary.

A system of draining wet lands by tapping the springs, was much estimated some few years ago. It consisted in boring large auger holes in low grounds into the tail of the stratum in which the water flowed, and from which it burst upwards in higher grounds and drawing the water to the auger holes. The plan succeeded or failed according as the strata in which the water flowed were regular or irregular, continuous or interrupted. Failures were most frequent, as might be expected; and for the purpose of carrying away surface water the plan was wholly useless. Even where it succeeded, it was seldom very strikingly more beneficial than the old mode of running a drain to each spring, for this drain in its course frequently intercepted other sources of wetness, or the surface water that flowed near its course. The specific success was confined to the springs flowing in sands and gravels, and where they formed the sole source of wetness. Draining of lands on that system has been altogether discontinued for a long time past.

Tapping of springs

now disused.

The modern system of draining differs from the old only in making a greater number of drains, and hence it is often called the frequent system. The same shape of the drains, the same mode of digging, and mostly of filling, yet prevail. The frequency of the drains carries off all the surface water, and intercepts the springs on the land, if any exist, and thus effectually answers both purposes.

In the modern system of draining, three things are chiefly to be considered: the frequency of the drains, the depth, and the mode of filling.

The frequency of the drains will depend on the tenacity of the upper soil, and the nature of the subsoil, if it be pervious, impervious, or mixed. In pervious and mixed subsoils, the water will flow into a cavity from a distance in the permeable strata, and consequently the drains may be farther apart; but in tenacious soils, and in compact impervious subsoils, the water will not percolate or flow to any distance, and consequently the drains must be nearer to each other in order to afford a ready egress to the superabundant moisture. The most tenacious clay soils may not require a nearer distance than four yards: some writers state five yards as the closest draining that any lands may require; but in pure plastic clays which form the extreme cases, it is better to err on the safe side, and to have rather more drains than too few, and thus repeat the old error of a non-effective performance. A distance of five yards will drain very wet lands, but instances are not wanting where four yards may be required. A distance of not more than eight yards will be required to drain the most permeable soils and subsoils, and the general distance of four to eight yards may be stated as being required for the soils and climate of Britain, ranging between these two numbers, according to soil and situation. Of these circumstances, the practitioner must judge from appearances; in many cases the herbage will give a fair idea of the nature of the soil; aquatic plants indicating the superabundance of moisture from below, and the altitude or hilly nature of the

Frequency of drains,

how indicated.

country will give intimation of the quantity of rain that may be expected to fall, and of the number of drains that may be required when both circumstances are considered. The skill and judgment of the chief operator must be duly and very fully exercised on these points. A local knowledge is best; but as it is very seldom to be got, the next best, or that of practice and experience must be used. Mistakes are often committed from want of the observation and consideration which these two points require—the two essential points on which the whole matter rests. On no point in the practice of agriculture is there more room for the exercise of skill and judgment, for a mistake is productive of much more mischief than in most other cases, being widely spread in its effects, and difficult of remedy.

Much judgment required.

The depth of the drains must also be regulated by the nature of the soil, and the dryness or humidity of the climate. In pure clays, where the effect of the drain is wholly confined to the carrying away of surface water, the drains cannot be too shallow, provided they are not disturbed by the plough or the feet of the animals. All the moisture or water to be carried away lies on the surface, and consequently the readier access it finds to the drains the better. But impervious and mixed subsoils, where the under-water flows in horizontal or vertical strata, the drains may be deeper, in order to find a firm foundation for the materials with which the drain is filled; though the propriety is questioned, and is certainly very questionable, of cutting drains any deeper than where the water is first found, and there to commence filling the drain, always supposing a firm foundation to be first found. Deep drains require more materials to fill them, and create more expense, both in filling and in digging; but in permeable soils, they may be useful in draining water which may flow in a stratum that edges or throws water upwards between the drains. Drains removed to a depth beyond the reach of the surface water, are wholly useless for the purpose of removing it, and much money and useless labour have been expended in digging downwards to cure the evil, when the remedy lay wholly upon the surface. In our climate, and upon the generality of our soils, a depth of two to three feet may be stated as a fair average; water lying or flowing below that depth can inflict no damage on the upper soil, and if the drains are made deeper, they may be removed beyond the reach of the surface water. Various depths have been mentioned by writers, and even by practical men, which are not worth much discussion, as they seem to have proceeded more from fancy and bare matter of opinion, than to be grounded on experience or on any specific solid fact. The depth now stated is sufficient to intercept the permeable strata, and does not require any large quantity of materials to fill it to a proper depth from the top, or render it accessible to the surface water, and these are the very special purposes of draining, viz., to carry away the surface water, and at the same time drain the under-water that lies within the reach of damaging the upper soil.

Depth of drains,

two to three feet.

Stones have ever been universally preferred for the purpose of filling

drains, but in many countries they are not found, and other materials have been used, as brushwood, stubble, and twisted straw. Modern invention has supplied the place of stones, and by the substitution of tiles, which are composed of puddled clay moulded into the proper shape, and then baked in an oven or kiln, to a hardness that resists the action of the vicissitudes to which they are exposed. This invention must be reckoned one of the most valuable of modern times, for it converts matter into the means of improving itself, and the most tenacious clay into a mode of making itself productive. The ductile quality of clay allows it to be moulded into any form, which in the present case is about twelve inches long, and arched into a span of four inches. Other dimensions are used, but the shape now given has been found to be well adapted for the purpose. The width of the drains at the top may be about two feet, sloping to six inches in width at the bottom, in which the tile of four inches is laid. It has been found by experience that the constant percolation or oozing of water on the bottom of a drain, even of a hard and tenacious clayey nature, creates a softness in which the thin edge of the tile gradually sinks and obstructs the arched passage, assisted by the superincumbent weight of the filling materials. This circumstance has rendered necessary the use of soles or flat tiles that are laid below the arched tile to prevent the sinking, and in common practice, a piece of a broken sole is laid below the meeting corners of the arched tiles, and bears the pressure of both. A quantity of straw, or a turf laid with the grassy side downwards, is put over the tile, and the excavated earth being thrown promiscuously to fill the drain, the process is finished.

Materials of filling.

Width of drains.

In the filling of drains with stones, the materials are broken with hammers, to the size of the largest road metal, either in the quarry where the stones are dug, or on the sides of the drains where the unbroken materials are laid. Stones dug from a quarry are preferable to stones gathered on the surface of the ground, as they afford more angular points, and consequently a greater number of interstices in the drains; when the stones are broken on the sides of the drains, the bruised materials are very conveniently lifted into the drains by means of baskets, without any earth getting intermixed. When they are dug and broken in a quarry, earth or rubbish of some sort will generally get mixed with them, and it is essential that no earth get into the drains. A screen is very easily constructed and placed on a wheelbarrow to be moved along the side of the drain as it is filled, provided with a wide screen to turn the stones into the drain, and a narrower one to throw on the ground the rubbish that passes through the wider bars of the upper screen. The carts come alongside the screen, into which the stones are thrown from the carts by hand shovel, the large bulks run into the drain, and the rubbish falls on the land; and with care and attention very sufficient work is made. But in general it may be recommended, that the stones be laid unbroken on the sides of the drains; that they be broken on a platform of boards, filled into baskets, and placed into the drains, and immediately covered

Stones, how used.

Covering of them.

with turf and earth. It is necessary that the drains be not allowed to remain long open and unfilled, nor the stones be allowed to lie uncovered after being put into the drains. In this operation, as in all others of a similar nature, systematic dispatch must be studied, the different operations must go on simultaneously, and be so arranged, that the execution of one part does not overreach the other, in order that the unfinished portion may sustain no damage. The earth crumbles into drains lying open, and causes labour in shovelling it out before the stones are put in and the same objection holds with stones placed in drains and lying uncovered.

It is very convenient when land can be drained in a state of grass, on account of the superior cleanliness and neatness with which the work can be performed. This very great advantage will most amply compensate

Grassy turf useful.

for any additional expense incurred in digging the drains during the hard season of summer, which may sometimes happen, and sometimes not. The lines of the drains being first marked by pegs or turves, the unbroken stones may be laid alongside at convenience; the grassy turf must be pared off thinly, and laid aside, and carefully preserved for covering the broken stones; the drains may then be dug to the full depth, and immediately filled with the broken stones to the height of twelve to sixteen inches from the top; the stones levelled with an iron rake, and the grassy turf laid neatly over them, and the earth shovelled in upon it. The broken stones should be put into baskets, and handed to a man standing in the drain, who will empty them in the proper place, level the stones, and lay the grassy turf neatly over them; and it is essential that this part of the business shall be performed by a confidential person specially appointed for the purpose, and whose contract bears a greater remuneration for the proper execution of it. The quarrying and breaking of the stones, the digging of the drains and the filling of the earth, may be let to be done by contract; but the filling of the drain with stones, and the laying of the turf over them, should be performed by

Filling most carefully done.

a fixed daily or weekly remuneration, where there is no inducement to hurry over the work imperfectly, as is generally the case in contract work. Work that is exposed to view may be mended when seen to be imperfectly performed, but a drain when covered is hid for ever, and the mischief remains. Much draining has been spoiled and money uselessly expended by the work being improperly executed on an erroneous system: contract work requires a sharp oversight, and in whatever way draining is performed, it claims much attention, being easy to spoil, and difficult to remedy.

In digging drains it is advantageous that the cavity is sloped to a very narrow bottom, as the stones, in being put into the drain, catch on the sloped sides, and form a kind of artificial arch, and afford a greater cavity, or more interstices below. When tiles are used, the bottom of the drain may be made the breadth of the tile, or a little more.

Broken stones laid in a drain over the tile about a foot in depth, has been called the "ne plus ultra" of draining, as it affords a clear pas-

"Ne plus ultra" of draining.

sage for water in the tile, and the upper space occupied by the stones is open and porous for extracting and conveying the water downwards. In the case of the tile alone being used, and covered, as it generally is, with straw, or a thin grassy turf, these substances are soon compressed and decay, and then there is only the space occupied by the tile, about four inches in height, to form a drain, both to extract and carry away the water. When stones are used, the half of the depth of the drain is filled, and thus affords an interstitial cavity of fifteen inches, for the purpose of receiving and discharging water. This circumstance constitutes the superiority of stones over tiles for the purpose of draining: they also form a stronger drain, and are more durable. Tiles are preferred where there is a constant current of water; in such cases, where stones are used, a square culvert should be set with broken stones, of a size proportioned to the quantity of water it may have to contain. It is necessary that a constant current of water have a free unbroken course. The receiving drain at the lower end of the field, must be wide, and have ample space both in width and depth—a depth of some inches below the common drains, and a width sufficient to contain a square set culvert of large unbroken stones to convey the whole quantity of water from the drainage; if one culvert be insufficient, two may be made; and in the case of tiles, if one large tile, which are made for the purpose, be insufficient, two may be placed, if necessary. These receiving drains must be conducted with great care, where the common drains are discharged into them, built with solidity, and have a covering of broken stones and grassy turf over them. If the current of water be large or rapid, care must be taken that the bed of the current is secured by laying soles or thin stones.

Tiles.

When drains are being dug, it may be advantageous to lay on one side of the drain the porous upper soil which is first excavated, and on the other side, the subsoil which will be of a different nature. After the grassy turf or straw is laid neatly over the stones or tiles, this earth may be shovelled into the drain, and may be mixed, or the one preferred to the other. Where the subsoil is very clayey and tenacious, the upper soil may be first put in, and the subsoil put on the top, as the action of the air and the operations of cultivation may prevent its consolidating and denying a passage to the water downwards, as often happens when it is put undermost in the drain. But no damage may happen from both kinds being put in promiscuously, unless the clay be very tenacious. A depth of fifteen inches of earth over the stones or tiles will be sufficient to admit subsoil ploughing, and may not be too deep and deny a passage to the water.

Earthy filling.

When the pressure of other business over the farm does not allow the full combination of the operating force on the point of draining, it will be very convenient to dig the drains to half the depth, and to excavate the part that is left at the time when the materials are brought forward and broken, and then the two operations of digging and filling can go on together. It is of very great consequence that a drain

Digging.

be filled with stones immediately on being dug, on the same day, if possible.

Drains are generally run in three directions, upright, aslant, and across; and each mode has its advocates, according as circumstances have favoured the operations. Cross draining can only be done when the declivity of the land favours the descent of the water in that direction, and then it becomes a kind of upright draining, being upright to the fall of the water. The across and slant directions have an advantage in the ruts of the plough crossing the drains, and thus conveying the water to be carried off, while in the upright direction the ruts and the drains run parallel, and consequently the water may remain longer on the land before reaching the drains. A preference may be justly given to that direction, which causes the ruts of the plough to cross the drains, for it seems natural to suppose that the water will, by that means, make a quicker escape. But much land has been and is yet drained, by placing a drain in each furrow between the ridges, at distances of four to twenty yards, and keeping the open furrow over the drain; and it is contended that it forms the most effectual mode of drainage on pure clay lands, and that the drains must be no deeper than places them beyond disturbance by the plough and the horses' feet. The ridges are shaped and raised to a convexity to throw the water to the furrows, and it is there quickly let into the drains. This mode is still largely practised in many places, and it has proved both effectual and durable.

Direction.

Furrow draining.

The Duke of Portland was among the first practitioners in Britain, of the furrow draining, or frequent system; and the mode of placing the drain in the open furrow made by the plough, and sinking the cavity no deeper than beyond disturbance by the implements of cultivation, has always been used, and is yet followed over all His Grace's estates, and was seen in full operation by the author of this work on the stiff alluvial clays in Ayrshire, in the west of Scotland, on the estate of that nobleman. After all that has been done, spoken, and written on the subject of frequent draining, the above practice may form the simplest and most effectual mode that is yet known; and His Grace's very true and most just opinion on the subjects, is very deserving of being recorded:—"That on all purely clay soils, the drains cannot be too shallow, provided they are not disturbed." Place the drains in point of number within the quick reach of the water, and afford to the water as quick a descent to the cavity after it has reached the surface of the drain. These two provisions constitute complete drainage, and both must exist, as one is useless without the other.

Duke of Portland's method.

His maxim.

Circular or pipe tiles have lately been introduced, which fit into each other at the ends, and thus form an uninterrupted channel. The diameter has been reduced so low as one inch—much too small an orifice to form a drain. The largest tiles are sometimes deficient in forming a cavity large enough to form a drain, and experience has taught all drainers to increase rather than diminish the size and capacity of the open portion of the drain. It is on this account that stones are so very

Pipe tiles.

much preferable to tiles, in forming an interstitial cavity of broken stones in place of four inches afforded by the tile, for the purpose of draining and carrying away the water.

Pure clay soils admit the stones to be small broken, as there is no current or muddy oosing of water to require large passages. But in mixed subsoils of sands and gravels, where are found outlets and oozings of water, the stones may be of a larger size, as they form larger openings and interstices for the passage of the muddy liquid. On soft bottoms where the stones sink by their own weight, it is necessary that some flat substance be laid underneath them. Soles are used in tile-draining; and for stones, slates have been very much recommended, and no doubt will prove to be very effectual, but the expense will be considerable, and flat shaped stones may be used, or any rough unbroken stones may be thrown into the drain till a bottom be formed by their weight sinking them, and then the broken materials may be put into the drain as usual. These points require much attention in draining; a neglect even in one single place may defeat the purpose of an entire length of drains, cause obstructions, and much expense and labour in removing them.

Soles for sands and gravels.

The very first object to be considered in commencing the operation of draining, is an outlet for the collected water, and for this purpose, the brooks or rivulets must be very carefully examined, deepened, and straightened, where it is necessary; the second consideration is the large drain, whether covered or open, that receives the water from the small field drains, and conveys it to the brook. It must be of sufficient width and depth, and convey the water freely away, without any stoppage or obstructions. An experienced operator will commence with these examinations, on which depends in a very great degree the success of the intended scheme.

Very much good has been effected on the Cheviot mountains and the Southern Highlands of Scotland in improving the sheep pastures, by cutting open drains for surface water with the spade, in large sods from sixteen to eighteen inches wide, and laying them on the under side, as the drains are chiefly run along the slanting sides of mountainous grounds. The cut is then cleared out to the depth of about fifteen inches, and the loose earth is likewise thrown to the lower side, so as to make a bank.

Hill draining.

These drains by removing the surface water, have proved of essential service in preventing the rot among sheep in moist pastures. An early bite of grass may be procured for the sheep by throwing the water over convenient grounds by way of irrigation, and these two advantages make this kind of draining one of the most useful improvements of the present day.

When springs of water are found in land to be drained, it will happen that the straight lines of the drains will pass on each side, and leave the outlet untouched; in that case, a drain must be cut, and run with the necessary declivity from the set drain to the spring, and a tile must be laid, or a square culvert set with stones, to convey the current to the drain;

Springs of water intercepted.

and if the current of water be strong and constant, it will require a tile, or a stone culvert to convey it to the receiving drain at the end of the field. An oozing of water will find a way among broken stones; but it is much better that a current have a free course in a tile or culvert. The ends of all drains that remain open should be built up firmly with square stones to the height of the drain, leaving a square mouth of discharge for the water. The joining of small drains with receiving drains must be made of the same height, and covered with the same turf and earth; and all such work must be done by an experienced confidential person, and the whole carefully overlooked and superintended by the chief operator. In no agricultural business whatever is more care and attention necessary than in draining, and nowhere does carelessness and neglect operate more forcibly and to greater disadvantage.

All drains covered.

It is advantageous that all drains or ditches be covered, that no open drains remain anywhere visible within the enclosure of a field. Covered drains admit the plough close to the fence, and allow the live stock to obtain the shelter of the hedge by standing close to it.

The expense of draining, like that of every other operation and performance, will vary according to circumstances as the cost and distance of the carriage of the materials, and the price of labour required to apply and adapt the materials to the purpose. A variation in draining will also happen from the greater or smaller number of drains that are required on an acre of land, and this circumstance itself must vary according to the extreme or moderate wetness of the soil. All these circumstances combined require a wider range of figure than at first sight would appear to be necessary, and to the reasons above given there must be added the nature of the soil, if it be hard or soft for digging. The expense will range from £4 to £8 per acre, according as the favourable or unfavourable circumstances may predominate; an average may be stated in £5 or £6

Expense of draining;

an acre, when the drains are five or six yards apart, which width will drain moderately wet lands. This estimate is confined within the hedges of the field to be drained, all exterior operations, as the cutting of open ditches, and of water courses, must be charged to the account of general expenditure.

The expense of draining being very considerable, and the nature of the improvement being permanent, it is both natural and reasonable that it be performed at the expense of the party who has a permanent interest in the land on which the improvement is performed. A yearly tenant of land is debarred by common sense from making any outlay of which he cannot reap the full fruits in the year of tenure; a farmer with a short lease is

on whom it falls.

not much better situated. A lease of not less than twenty years, at least, is required to justify such a costly improvement as draining at the expense of the tenant, that he may have a fair chance of being reimbursed for his outlay of capital. A farmer, even with a lease, has only a temporary interest in the land he occupies—it is contrary to human nature to expect that he will take as much trouble in the performance as if he had an interest at stake, and consequently the cost of the

improvement reverts on the proprietor who enjoys the perpetuity of the value. Accordingly, the most equitable arrangement seems to be that the improvement be effected at the cost of the proprietor, the tenant paying a yearly interest for the money expended, and the cartage of the materials as an equivalent for the benefit he may derive from the improvement that has been effected. The work being done by the proprietor's own workmen, he has the greater security that it is properly done; a vast advantage over the draining being entrusted to persons who have only a temporary interest in the performance. Various arrangements have been made between landlord and tenant; as the former giving the tiles, and the latter digging the drains and filling them; and otherwise each party paying half the expense. The most common, and the most equitable arrangement consists in the landowner making all the outlay, and the farmer paying five per cent. interest on the outlay, during the period of twenty years: and otherwise, the tenant pays 5*s.* or 6*s.* an acre for the drained lands, along with the rent, in half-yearly payments. This last mode will give the landowner three-and-a-half to four per cent. yearly, for the money expended, which may be sufficient when the national funds are taken as a model. This last arrangement was from the first adopted, and is still used by the Duke of Portland, whose excellent practice has been already mentioned on several rural undertakings. His methods and calculations are never exceeded by any subsequent attempts, but remain as rocks fixed in the bottom of the sea, that are never lifted up and down by tides. In all arrangements, the proprietor must have the work done by his own agency both in labour and superintendence, as he has the security of its being permanently effected. The farmer by doing a stated portion of the performance, buys the yearly fruits of the improvement, and at the end of twenty years, the negotiation is terminated, and the improved ground becomes an article of commerce in the altered condition which has been imposed upon it. A wealthy tenant may be induced by a lease of twenty or twenty-five years to drain lands at his own cost which are the property of another person; but the cases are few, and there is yet a great aversion to grant the necessary security which is essential to the business. Security begets confidence, and confidence promotes that thirst and eager desire of remuneration which does not exist unless self-interest be enlisted in the cause, and which so effectually ensures the advancement and economical termination of any intended scheme. Terms of agreement regulate the moral excitement, which is keen or blunt as the conditions may be encouraging or unfair between the parties.

Various arrangements.

Duke of Portland's method

of all ways the most equitable.

The draining of lands that are wet, either from springs of water from below the ground, or from the aluminous composition of the soil holding the moisture too long, and causing damage to vegetation, or as often happens from both causes must precede all other improvements that may be intended to be undertaken under the circumstances now described. Experience will direct whether a thorough frequent draining be necessary to prevent the damage of a general wetness, or a less frequent drainage

to carry away the hurtful effects of springs, aided by a partial wetness of the soil; but in every case the drainage should be more frequent than less frequent, in order to produce at once a sure and certain result. No pro-

Value of draining.

prietor of land ever can find a more profitable or a safer investment for money—he has the security on his own property, in addition to the improvement of it; and it has been stated, as an average calculation, that land thoroughly drained, and properly managed otherwise produces three crops in two years, in comparison with the former produce. The farmer has the advantage of more produce from his lands, the texture improved, and more easily wrought and accessible, and a more grateful and a sweeter herbage. The circumstance of draining rendering lands easier and sooner accessible at the different periods of working, is a recommendation of itself sufficient to show the great value of the improvement, besides the increase of produce in every crop that grows. Experience has not yet recorded the fact, if draining has in any case converted stiff clay lands into turnip loams: if it has happened any where, it may have

on any lands.

arisen from a constitutional near alliance of the soil, or from the nature of it approximating to loam, and wanting only the abstraction of the water, and but little alteration in the texture. Clay soils may probably be placed beyond that degree of alteration.

It has been objected to draining that it destroys the viscous tenacity in the land, so necessary to the production of wheat and beans, and may carry off in the shape of water the saline and soluble salts in the soil. But these evils may exist only in imagination and anticipation, and may in effect be only partial, and may not detract much from the general value of draining. The effects of it have been found so very superior to that of the viscous tenacity and that of the soluble salts in the wet state of the land, that little hesitation will be entertained which of the two conditions of the land must be preferred for practice.

Objections not tenable.

It is certain that draining has not in every case been attended with success, and that in many instances it has been accompanied with loss of capital. This result may be ascribed to two general causes: the want of knowledge or caution in the application of the system to practice, and to the defective execution of the works, in cutting and filling the drains, and in the materials used. True economy consists in getting work well done, not in the cheapness of execution; and a very general mistake is constantly committed in placing the tiles too deep, and too small a quantity of porous materials over them; thus repeating the old error of having useless drains deeply imbedded in compact clay, and beyond the reach of the surface water. But the occasional failures of draining are not more frequent than other miscarriages, the chance of which attaches to

Failures few.

proceedings of every kind. A neglected execution will mar any purpose, and a careless application almost renders a failure to be certain.

In order to derive the full effects of draining, it must be followed by an improved treatment of the land in every respect, as to cropping and manuring, in order to repair the damage they may sustain by the supposed

loss of tenacity and of saline soluble matters. When land is drained in a state of grass, there will be fresh matters in the soil for decomposition, and then the liberal application of calcareous matters becomes very highly necessary and desirable. It has been admitted in all ages of the world, that the draining of marshes and of stagnant waters is highly conducive to health and salubrity; and we may very reasonably suppose that the close draining of wet lands, though performed on a smaller scale, will operate in a similar manner. It carries away or prevents the generation of the pestilential miasms that originate in distempered and poisonous bodies, and lime arrests the noxious effluvia that tend to rise more or less from every soil at certain seasons of the year, and decomposes them, or causes the elements to assume new forms of chemical combination, in which they no longer exert the same injurious influence on animal life. How beautiful a consequence of agricultural skill that the health of the community should be promoted by the same methods which most largely increase the produce of the land! Can it be doubted that the All-benevolent Creator of the world places this consequence so plainly before mankind as a stimulus to further and more general improvements, to the application of other knowledge still to the amelioration of the soil? What noble employment for the mind of man! By the use of his reason, his energies, and his capital, he affords in the first place, employment for his fellow-creatures, then an increase of food and of health to the human race; and lastly, a remuneration to himself. What more can his heart desire? There is nothing wanting to satisfy either the selfish or the philanthropic mind. A very heavy and unextinguishable responsibility rests on those persons who possess the means and the power of conferring such invaluable benefits on the human race, and neglect the very valuable opportunity of lightening the debts of property to poverty; and who continue ignorant and unwilling, or incapable of action, in spite of the warnings of science and the sanctions of experience. Under the wide expanse of heaven there is not and cannot be a more gratifying employment than the improving the condition of the human race; and as the physical condition must ever precede the moral, the improvement of which we are now treating, must claim a prominent place among the agencies that may be employed in effecting that object. There is a huge difference between the employment we are now describing and the many fooleries that engage the attention of the human race, that degrade the intellect, vitiate the morals, and debilitate the bodies of men. Here is employment, food, and health, to be derived from a source the most rational under heaven—from the cultivation of the earth, the inalienable patrimony of the human race. It is not a little surprising that any draining should remain unperformed, the proofs of the beneficial effects being so many, so strong, and undeniable. The results, as we have shown, are not confined to the benefit of the individual who performs the operation; they swell into national importance, and claim the attention of the philosopher and statesman, as well as of the cultivator and owner of the soil. Every interest must give way to the general

Consequences of draining.

General,

Universal,

to every grade of society,

interest; but here is no opposition, or any jarring contention, for every party is benefited, and the general good promoted. The labourer finds employment; the farmer obtains an increase of produce; and the land-owner gets his property improved in value, and a remuneration for his capital; the nation enjoys a climate improved and salubrified by the process, and an increase of food, the essential element of life, on the regular and ample supply of which articles the prosperity of any social community almost wholly depends.

individually and comprehensively.

CHAPTER IX.

MINERALS—WORKING AND VALUE.

Mineral property is very frequently the most valuable part of a landed estate. The income is generally steady and secure, and not so uncertain as the revenue of the capitalist and the trader. Extensive mining infers the advancement of a large capital; and an adequate knowledge of the subject should be present before commencing too rashly in the works of digging minerals. There are many cases in which the land-owner may profitably embark his capital in mining; but in most cases it is preferred to lease out this species of property to others, who advance the capital and follow mining as a profession.

Minerals.

The metals of Britain are—copper, tin, lead, and iron. The useful minerals are—lime, coal, clay, and building stones. Copper lies chiefly in the older rocks of primary and transition, and is found in many conditions, but chiefly in the ores of sulphurets. The most important of the ores of copper is copper-pyrites or yellow copper ore, which is a compound of sulphuret of copper, and sesqui-sulphuret of iron. It is found in granite, the trap rocks, and even in the lava of recent volcanoes. Although more difficult to be reduced than iron, it was more extensively employed by the ancients, who understood the art of hardening it, so as to form cutting instruments, by mixing it with tin and other metals.

Copper,

The primary and transition deposits of Cornwall, that are intersected by porphyries and other plutonic rocks, afford the richest mines of copper that are now worked, which lie in the tract of country between Truro and the Land's End. The veins traverse the slaty rocks or killas of the provincial nomenclature, and are collected into groups, and do not cover a large extent of surface. The directions are various in which the veins run their course, which is never vertical, but at an angle with the horizon. The depth is not known, the search being generally abandoned on account of the poverty of the vein, or the increased expenses of sinking. The average width is three feet, some are six and even ten or

in Cornwall;

twelve, with smaller ramifications. The length is under two miles, though some reach to seven. The depth is great, extending to 1650 feet below the surface of the ground, and many cases approach to that level. The driftways and levels under ground amount in the aggregate to hundreds of miles. The mines extend under the bed of the sea; and the dashing of the waves, and the rolling of the pebbles and fragments of rock, are heard by the workmen in the excavations below.

A very rich mine of copper was wrought in Anglesea, which for twelve years, from 1773 to 1785, lowered the price of the metal throughout Europe. The produce diminished, and the mine is now only moderately productive. Some other places afford copper in limited quantities—as Devonshire, Derbyshire, and Staffordshire, the Wicklow Mountains, and the Isle of Man. The transition mountains of Scotland show a small quantity; and a mine has been opened in the Zetland Islands. No rock above the coal in Britain contains copper; but in Germany, beds of what are called copper-slate exist in the new red sandstone.

in Argyleshire.

The brass of the Romans meant copper, which must have been very early worked in this country. The Crown gave up its right to all the baser metals in 1688, when England did not produce sufficient copper for its own use; and the copper coinage of native metal did not appear till 1717. From this period the increase of copper has been amazing, and now exceeding 14,000 tons, being in the one-half exported, and over one million of money in value.

Smelting.

Sulphur, iron, and other substances are associated with copper, and require, in being separated from it, a much more complicated series of operations than iron or lead. The smelting establishments are quite distinct from the digging of the metal, which is sent to the former as a raw material, to be prepared by a different division of labour and of firm. The same hands do not often possess both undertakings.

Quality.

The metal of copper is very malleable, and may be hammered into plates of great fineness. The substance is of great value in the arts. Iron only exceeds it in tenacity, which is superior to that of gold, silver, and platinum. The alloy equals the single value—three parts of copper and one of zinc form brass; one hundred parts to ten of tin, it forms bronze and gun-metal; with twenty-five of tin, it forms bell-metal; with thirty-five of tin, it forms optical speculæ, which were formerly used as mirrors.

Value.

Very few localities can be expected to yield copper in any workable quantity. The value is inferior only to the precious metals, and the mineral is very profitable on an estate of land; but much caution is due to the engagement in working it, and must ever be done under the direction of a skilful engineer.

Tin is a scarce metal, yet was early known to the nations of Europe, who seem to have derived the supply from the inhabitants of Tyre. It occurs in the primary rocks, in veins, or disseminated, and in two mineral species, the peroxide, called tin stone, or tin ore, and the cuprcous, sulphuret or bell-metal ore. The metal is abundant in Cornwall, and is

found on the continent of Europe, and in the East Indies. In Cornwall
Tin. the veins extend from a line to several feet in thickness, and are of unknown depth, being wider in the softer rocks than in the granite. The veins are wrought by vertical shafts and by drifts underground that extend for many leagues. Stream tin or grain tin is gathered in the ravines and valleys, where it lies mixed with sand and gravel in grains or larger fragments up to twenty pounds in weight. The ore is separated by washing, and sells at a lower price than the block tin of the veins.

The purifying of tin is a tedious process; the ore is first reduced to powder by stampers, and washed and sifted, so as to separate the tin from the other mixtures. The heat of a furnace then banishes the sulphur and arsenic from their combinations, and washing separates the substances. The ore is then fused by lime and coal; the lime combines with the earthy
Working. matters, and the coal reduces the oxide to the metallic state. It is again further purified by fusion, and cast into blocks, which are stamped for commerce. About 4300 tons of tin are produced in Corn-
Quantity. wall, of which the one-half is exported. The locality of tin is very limited, and forbids any hope of a successful search in Britain. Some deposits of stream-tin may probably occur in the primary districts of the west of Scotland and Ireland.

Lead: Lead exists only in one abundant ore, which is the sulphuret or galena, or lead glance. The mineral occurs in veins of varying thickness, in the primary or transition districts, partially in the old red sand stone, abundantly in the mountain limestone, but sparingly in the coal measures, or the superior formations. The chief positions in Britain are the slaty and greywacke hills, which stretch across the island from St. Abb's Head to the Irish sea; in Derbyshire, Shropshire, Devonshire, and Cornwall; in the Isle of Man; in Denbighshire and Flintshire; and in some parts of Ireland. The mines have been worked in Scotland since 1540 with considerable profit, in the slaty and greywacke rocks of the counties of Dumfries and Lanark. The thickness of the veins varies from four to ten feet and upwards.

The elevated country near the Cheviot hills, in the north of England, around Crossfell, where the meeting happens of the counties of Northum-
where found. berland, Durham, North Riding of Yorkshire, Cumberland, and Westmoreland, contains the mines of lead that are the richest in England. The number is 175, and have been, or are now worked. The rock of mountain limestone, with its accompanying strata of sandstone and slate, contains the mines which are situated in the five counties. The directions of the veins are various, and are sometimes very slender, and at other times thick, as fifteen feet or more. The best are in the limestone; and the quantity and quality are contracted in the slate and sandstone. Trap in dikes intersect the veins, which are very productive, and have much increased the value of the landed property.

The oldest mines are in Derbyshire, and the richest in North Wales, which yield fully one-fourth of all the lead in the kingdom. Many or all

these mines have been worked out or destroyed by inundations. The average yearly produce of lead in Britain is about 50,000 tons, and at £20 per ton the value is about one million sterling. About one-third of the produce is exported. Quantity.

Lead-glance is the chief ore, and the extraction of the metal is not very difficult. The sulphur is driven off as acids, and the metal is oxidated by the action of a powerful heat; a part of the sulphuric acid combines with the metal, and forms sulphate of lead, to reduce which quicklime and coal are added during the process; the lime combining with the sulphuric acid, and the carbon of the coal abstracting the oxygen of the metallic oxide. The metal being reduced, is collected in vessels, from which it is cast into large ingots termed pigs, and is ready for commerce. Working.

Silver, iron, and copper, are in a small quantity mixed with common lead. The silver is extracted, when the quantity defrays the expense; but the amount and value are inconsiderable in this country.

The hazards are large of mining and smelting, and metalliferous veins are irregularly disposed, sometimes disappear, and are cut off when the indications appear of the largest returns. They are consequently placed beyond the calculation of coal and stones, which lie in beds, and admit an approximate relation of the raw material with the exterior approach. The number and thickness of the veins must determine the expediency of working, and the proprietor will be guided by the best advice on the subject. Risk of Mining.

Iron is the most useful of all the metals, and enters everywhere into the composition of the larger masses of mountain rocks, and in combination with oxygen, sulphur, silica, and other substances, forms many mineral species. The ores are numerous, but two of them furnish the useful metal in magnetic iron and clay ironstone. The former yields the iron of Sweden and Norway, and occurs in beds or single crystals in the older rock formations, and combines the two oxides of red and black. The ironstone is found in the coal measures of Britain, of which the whole consumption is supplied from that quarter. It is a happy advantage, the coal and lime necessary for the smelting the ore are found together, as the geological deposit has placed the formations. Iron.

Iron occurs in beds, that are from one inch to a foot in thickness, and alternate with shale, limestone, and coal. The ore is put into large furnaces, where a powerful heat is raised by common coal mixed with lime as a flux. The oxygen is banished by the heat, while the lime combines and carries off the foreign matters in a fusible compound called slag. The melted metal by its density sinks to the bottom, where it escapes by a hole plugged with sand and clay; the slag floats upon the surface, and escapes by an aperture in the side of the furnace. The process of fusion goes on continually, as fresh matter is constantly supplied from above. The liquid matter received from the furnace is run into moulds of sand, and then it forms the pig-iron of commerce. Where found. Working.

The furnaces are square at the bottom, where the metal collects, and

then swell outward to their greatest diameter, when they contract to the commencement of the chimney. They are built with bricks or stone, and lined with fire bricks; the hearth at the bottom being a hard infusible stone. A tunnel head, or an external gallery, at the beginning of the upper part of the chimney, contains square openings with iron doors, by which the furnace is charged with materials. A most intense degree of heat is raised by blowing pipes, which are driven by steam power, and holes introduce the streams of air in the lower and narrower part of the furnace. The fuel is coke or common bituminous coal; and a saving of these matters in the one-third to one-half is effected by heating the air before entering the furnace, by passing it through heated pipes that are placed between the furnace and the blowing apparatus: iron is more brittle produced in this way than by means of coke and cold air.

Smelting.

Before being put into the furnace, the ore has been exposed in heaps to the air, for the purpose of banishing water, carbonic acid, and sulphur. Ironstone, coal, and limestone, are then introduced in twenty cubic feet of coal to the corresponding quantities of iron and lime. The liquid metal is usually drawn off every twelve hours; and the furnace being once ignited, is never again extinguished till it needs reparation. The metal is conveyed into its moulds under a shed by the side of the furnace.

Furnaces.

The iron is impure as it comes into the first melted condition, containing foreign bodies, chiefly carbon, and is hence regarded as a carburet. It is fusible, and may be moulded into many fabrics. It becomes tenacious and ductile, but more infusible, and formed into soft or malleable iron by a further series of processes, by which it is freed of its carbon and other impurities.

The pig-iron is fused in a peculiar kind of furnace, and formed into a slab, which is rendered brittle by throwing water upon it. Being broken into pieces, a reverbatory furnace subjects it to the operation of puddling, which consists in stirring it while in a liquid state, when a large disengagement will happen of carbonic oxide, as is known by the blue flame. Balls are then formed of the iron, and forged by heavy hammers, or are passed while hot between a series of grooved rollers. This condition is called mill-bar iron. The forging is continued by welding pieces of it together, and the properties are further acquired of malleability, ductility, and cohesiveness.

Pig-iron.

The iron thus prepared is the valuable substance of malleable iron, fusible only by the most intense heat that can be produced by any artificial means. The malleability is of any temperature, and increases with the heat applied; when red hot, it may be hammered into any forms, and welded or joined in any fashion. It is very ductile, and may be drawn into thin wires, when the supporting power exceeds all other metals. Combined with carbon, iron forms steel.

Steel.

Iron is generally melted where it is found, as coals and lime are in contiguity. The mines of Britain are in North and South Wales,

Shropshire, Staffordshire, and Derbyshire; and in Scotland, in the vallies of Forth and Clyde. Mines in Britain.

The improvements of the smelting processes, and the use of the steam engine, have increased the iron trade most amazingly, from the middle to the close of last century, and the facility of an increased production had the usual effect of diminishing the price, and this result enlarged the consumption by introducing iron into many other purposes of use. The demand now must limit the production, as Britain seems capable of supplying the entire consumption of the world.

The mines of iron are let upon lease for a stipulated rent or royalty. The royalty is not reducible to rule, but must vary with the nature and richness of the mine, and other circumstances that affect the value of the produce. The land-owner may sink the new mine, and work it till the value can be approximated, when a tenancy can be negotiated. Very long leases are generally granted to companies or wealthy individuals, who make every erection, and perform all business at their own cost, without any demand on the original inheritance. Rent or royalty.

Coal is a very inflammable body, composed chiefly of bitumen with other matters, with much carbon in the hard varieties. The formation lies in great irregular basins, the strata dipping to some common centre, or general axis, and are found in the sandstones of the secondary class of rocks, which succeed the unstratified deposits. Where this rock is not deeply covered by the upper formations, the coal approaches the surface, and was early discovered for the purpose of fuel. It forms the chief mineral wealth of Britain, and employs a large portion of the shipping and mariners of the island. The regularity of the strata of coal is very often disturbed and intersected by dikes, fissures, and irruptions of igneous rocks, as traps, basalt, porphyries, and interjected argillaceous matters, which are found in every geological deposit from the granite to the chalk. These barriers run in various directions, vertical, oblique, and often right-angled to the stratum of coal; and are known by different names as dikes, slips, faults, and troubles, according as the dislocation of the stratum is greater or less, and affects the proceedings of the mine largely or in a small degree. Coal mines.

Coal is best discovered by boring, and the natural indications must be such as to induce that trial being made. Professional borers contract for the work, and are paid 5*s*. for the first five fathoms; 10*s*. or more for the second; 15*s*. or more for the third, and so on, in the same proportion for every five fathoms, or thirty feet in depth. The essential purpose of boring is to ascertain the depth and thickness of the mineral seams in the tract to be surveyed. The depth of the covering over the coal and the thickness of the strata, must be ascertained, and also the dip or inclination, which the coals assume in the extent of the surface ground. Declivities admit a day-level being made, which will draw off the water into lower ground, when it is best five or six feet in height, and four feet wide, built and arched with stones or bricks. Water will flow into every excavation made in the ground, Boring. Depth.

either from the looser earth of alluvial covering, or from the seams of solid strata through which it may permeate. In level situations, no inclination can be found, and pumps are necessary in order to raise the water from the bottom of the excavation to the surface, on which it is floated away into brooks or rivers; or it is discharged into a day-level, which has been described. In great depths, there is a large mechanical stress in the length of the piston rods, and the increase of weight and strength in other parts of the pump, when water is raised from the bottom, and therefore it is necessary to have a series of pumps, the lowermost throwing the water into a cistern, whence another higher pump draws it to a second cistern, and so on to the discharging orifice. The cylinders of the pumps are fifteen and eighteen inches diameter.

Levels.

Pumps.

Coals are reached by an engine pit, circular in form, and divided by partitions into parts, as the purposes may require, in placing the pump, for ventilation, and for raising the coals. The engine pit is frequently placed at the tail or lowest dip of the inclined strata below ground, to which the water flows, and the coals are raised at other places that are pointed by convenience. The coal pits are circularly lined with masonry, through the depth of the loose covering of the surface; the rocks below afford a solid boundary, and not unfrequently the wall is continued from top to the bottom, or planks of wood or thick boards are substituted. Sheathings of cast iron prevent the influx of quicksands, which were formerly thought to be fatal and altogether insurmountable. A peculiar arrangement joins the different segments.

Engine pits.

Water will flow into the pit that is being sunk, which must be removed by pumps that are successively lowered downwards as the works proceeds. A pump will very conveniently raise water to the height of twenty-five fathoms, so that three pumps will be required for the depth of seventy-five fathoms. The cisterns that receive the water at the stated distances, are fixed in the excavations made to receive them in the sides of the pit, as the excavation goes on; and the pumps are used in the first place to raise the water that flows into the pit that is being dug: they are afterwards placed in the position which they are to occupy. In some pits, the water is carried to the fixed cisterns by means of spiral boxes carried round the sides; but in all larger pits, the entry of water is prohibited by the cast iron sheathing that has been mentioned. The sinking of the engine pit constitutes the first grand work of the mine, and is termed the winning of the colliery. When the mine is won, the further operations consist in working the mineral, the division and economy of labour, the ventilation of the mine, and the removal of the water. In the vast coal field of the Tyne, the mineral lies deep under a bed of alluvial debris, and large depths must be sunk to reach and excavate the workable seams. One engine pit with the necessary machinery, has expended, £50,000; and even £80,000 and £100,000 have been in special cases, used in these purposes. Nothing could justify such large outlays, but the high value of this rich coal, which it has maintained for

Water prevented.

Cost of sinking.

centuries, and the seemingly inexhaustible source of the supply, which appears to meet the continued and increasing demand. In that locality, mining is seen in the perfected science, and engineering is exhibited on a scale of grandeur.

The coal lies in seams that are more or less inclined from the horizontal direction and which are parted by strata, which are more or less argillaceous, siliceous, or calcareous; the lower is floor, and the upper the roof, and the coal is parted from each, by thin seams of dry powder or clay; and the coal itself is intersected by series of subordinate partings, parallel to the main ones, consisting of a soft carbonaceous matter which blackens the fingers, and varying in thicknesss from a line to an inch and half. The mass is also cut by backs and cutters, which extend transversely at right angles to the line of dip, and longitudinally in the line of dip, and these divisions facilitate the working of the coal, and affect the methods of working. Seams of coal.

Two methods are used in working coals—one way leaves pillars to support the roof, and which remains in permanency, or being removed, the roof falls in and fills the mine; the second mode allows the roof to fall in regularly as the work proceeds. The first mode is the most common, and the most generally applicable. The engine pit is at once sunk to the most extreme depth, from which a mine is run which is termed the dip head level, and to it all the water in the mine s directed. A series of excavations is conducted in the line of ascent upwards, and another at right angles to these. The pump raises the water from the lowest level, roads are directed in various quarters, and one fourth part or more is left of the standing mass in order to support the roof. The progressive excavations of the coal divide the mine into numerous passages, which are called rooms or thirlings, and communicate with one general passage, that leads to the place in the bottom of the pit, by which the coal is to be elevated. This road is a double railway of cast iron, on which are run low trucks on four wheels, called rolleys, and are dragged by one horse, several trucks being hooked together. The excavated coal is placed in tubs, technically termed corves, made of osiers, or of hammered iron. They are put on small trucks with low wheels called trams, which are dragged through the low and narrow passages by manual labour. Each truck carries a tub or corf, containing four to six cwts. Boys drive the corves from the workings to the mainway, and lads drive the trucks along the mainway to the shaft. Ways of digging. Roads and trucks.

The miners, or hewers, work separately in assigned portions of work. The coal is brought down with light picks of iron, by wedges and drills, and sometimes with gunpowder. The room being scanty for work, the body reclines or sits, and in narrow seams, the back is flat on the pavement. The hire is by the quantity excavated, and the miner assists in loading the corves, which on reaching the mainway, are examined by the superintendent, and being passed his sanction, several corves are hooked together, the train is drawn by a horse rapidly along Hired—quantity.

the railway. Where the inclination is great, inclined planes, with machinery are substituted for animal power.

The corves having reached the bottom of the shaft, a strong rope with hooks and chains attaches a certain number, which are raised to the pit mouth by means of the rope being coiled round a beam which is revolved by a horse walking in a circular pathway; in all large mines, steam power relieves the use of animals. The corves are unhooked by attendants at the mouth of the pit, and dragged on rails to the place of deposition of the load. The empty corves are lowered by the elevating power working in another direction.

Elevation by machinery.

Ventilation is very necessary in every work underground, and fresh air must be made to circulate in every part of the excavation. Air pits are provided in the shape of wooden boxes, which communicate with the open air, or with some large opening that receives from it the necessary respirations.

Coal mines are very dangerously infested with destructive vapours that issue from the pores and fissures of the coal, and which accumulate in two dangerous gases, of carbonic acid gas, and light carburreted hydrogen. The former receives the name of coal damp, or choke damp; and the latter of fire damp, or foul air.

Gas in pits.

Carbonic acid being heavy, falls to the ground, and rolls along like water, in the lower part of the works, rising by degrees to the higher. It issues abundantly from the seams and fissures, forming a stratum of a foot or two at the bottom of the excavation, while a pure air is respirable above it. In the air above it, a candle burns clear; in the stratum, it is instantly extinguished. This gas is pernicious to human life, either pure or mixed with atmospheric air: when a candle will not burn in it, it is instantly fatal. Hence the precaution of lowering a candle to try the quality of the gas, and also the modern safe-guard of the miner carrying a lamp which by the faint burning warns the approach of danger. The general air of mines has a quantity of this gas, but does not prove deleterious.

Safety lamps.

The fire damp of mines is sub-carburreted hydrogen, and burns with a strong yellow flame. When abundantly present, it detonates with violence, and hence the danger of the explosion. Being light it flies to the higher part of the works, and hangs like a canopy over the heads of the workmen. A small quantity of it mixed with the common air, creates no inconvenience; but when pure, and without almost any mixture, respiring life does not exist in it. If ignited by the contact of a burning lamp, a terrible explosion takes place, attended with much devastation and loss of life. The gas is not ignited by any temperature below that of flame, and flame cannot be communicated through narrow tubes of metal. Hence a lamp was constructed by Sir H. Davy, the celebrated chemist, which is covered with a tall cylinder of fine wire that from the fineness of the texture does not greatly obstruct the light, while it admits sufficient air from without to support the combustion. When brought into contact with the inflammable air of the

Fire damp.

Now less dangerous.

mine, the air enters the lamp and supports combustion, but the flame of the lamp does not pass through the covering of wire gauze, and inflame the explosive atmosphere without. In extreme cases, air which enters the lamp will take fire, and the intense heat will oxidate the wires, and cause them to fall into pieces. This safeguard of a lamp against explosions, is not wholly perfect—but it has greatly reduced the number of explosions, and would still lessen the accidents, if due caution was observed. Miners are careless, and often open the lamps to trim them in spite of every admonition and the many fatal examples.

Private gain and public interest are equally concerned in the working of coal mines. A just rent can always be got for coal in proportion to the quantity of saleable produce, and the royalty varies from one-sixth or more, to one-fifteenth, according as the mine is level free, or requires an engine pit. When other minerals, as ironstone, are wrought along with the coal, a separate royalty is charged on the special article. The lease must describe the situation and extent of the mine, with a map made and signed by both parties. The mode of working the mine, the maintenance of the levels, and other general regulations, are also agreed, the landlord builds the specified accommodations, the lessee upholds them, and leaves all in tenantable order when he vacates the possession. The moveable machinery is erected by the tenant, and the landlord can buy it at the valuation of mutual referees.

Royalty on coals

The royalty is ascertained from the sworn books of sale by the tenant, and the owner may appoint his own agents as checks for his interest: and he can send into the mine at any time, surveyors to see that the mine is properly wrought, and all things are attended. The working must not touch any other mine by ten fathoms, nor go underneath any specified buildings; all pits must be arched over, and surface damages paid. Other conditions will arise from local circumstances, and occurring attachments.

known from the books of sale.

When coals are discovered, the proprietor of the ground sinks the pit, makes the levels, and puts all into current going order for operations. The mine is then let for a yearly rent: or a long lease on very equitable terms is given to the wealthy individual, or a public company, which uses the possession nearly as its own. In other cases, the proprietor is the sole agent, works the mine, and gets all profits. The charge of royalty is the most just and equitable for both parties, as it depends on the quantity sold, and does not rob one to pay another in an uncertainty. The quantity of coals excavated yearly in Britain reaches 35,000,000 of tons, and at 10s. of an average price the value amounts to £18,000,000. The one-half of the price belongs to the labour that has brought the coal to the mouth of the pit, and the other for the carriage to the port of delivery. The capital engaged in coal mining exceeds £10,000,000. The single seams of coals vary in thickness from one foot to forty, and the aggregation of a coal bed from that to 200 feet. The condition of the mining population has been much improved by private benevolence, and special acts of legislation.

Lease is long.

Lime. Lime exists in many combinations, but mostly as a carbonate, or an earthy base in combination with carbonic acid gas. The highly indurated and crystalline kinds form marbles; and the softer constitute the common compact limestone, magnesian stone, oolite limes, and chalk. All these rocks, being subjected to a strong heat above redness, yield the gas which holds the stone together, and becomes a light cinder, which on being slaked with water falls into fine powder. The mixture with sand becomes mortar for building walls of stones and bricks and the powder is used as manure for land.

Lime is mostly a flat rock, and lies in horizontal beds, that are divided by seams, and cross fissures, and differs largely from the veins from which minerals are extracted. Where the rock is uppermost in position without any stratified body being superimposed except the alluvial covering, the excavation of the stone is done by open cast, that is, in the manner of a quarry. An outlet for the water is first to be found in the natural descent of the ground—if none exists, a low point must be formed, and a pump placed over it, which will discharge the water into some opening or outlet.

Working. The earthy covering of the rock must be raised by spade, and wheeled by barrows to some side where no interference will be made with the works. When the limestone lies deep, the mining of the rock proceeds in the manner of coals. The rock of lime generally yields to the pick, hammer, and wedge: otherwise, it is bored and blasted with gunpowder.

Furnaces are built for the purpose of calcining limestone, in the elliptical form, narrowing to the bottom where the calcined lime is withdrawn. The egg-shape is used, when the wider end must be at the top, in order to receive the raw materials of broken stones. The exterior wall of the furnace is of thick masonry, and the inside lined with fire brick, or stones capable to resist a high temperature, and erected on a convenient ground to receive the stones that are intended to be burnt. It should stand at the bottom of a slope if possible, and the top level with the

Burning. mixed stones, which are put at once into the furnace, and the low ground gives access to the removal of the cinders of the lime as they are drawn from the opening at the bottom of the furnace. When a suitable situation is at a moderate distance, a railway will convey upon trucks, the stones to the furnace. The stones are broken by hammer into a convenient size, and put into the furnace with alternate layers of coals or wood. The fire being applied below ascends upwards, consumes the fuel, and banishes the gas from the stone, which is drawn and carried from the eye of the kiln, in a constant regularity with the filling of the stones into the top of the furnace. In this way the work never stops, and the supply is constant. It is computed that, in a well-constructed kiln, one bushel of the best coal will produce three of lime, and from one-third to

Drawing of cinders. one-half, according to the constitution of the lime, may be withdrawn every day. These proportions will vary, and as much as two-thirds may be withdrawn by extending the height of the kiln, lessening its diameter, and diminishing the width of the top. But

the calcination will be less gradual and perfect than when more time is allowed, and a smaller quantity withdrawn.

The proprietor may keep in his own hands the working of limestones; but it is generally let at a royalty that varies from one-sixth to a fourth of the proceeds, according to the quality and sale of the lime, and the distance and cost of fuel. When the royalty is extended to show an average of years, a lease may be granted, as for a farm of land, upon the moderated calculation that should direct the assumptions of value. Royalty.

Building stones are sufficiently strong to resist the pressure of any force applied to them, and durable to oppose disintegration from the power of chemical changes and external agents. Hardness and tenacity compose the first quality, and the texture forms the second. The closeness of the grain, the homogeneity of the mass, and in certain cases the specific gravity, indicate durability, and afford the only direction of judgment, independently of experience. A loose earthy texture is very unfavourable to durability.

Building stones are of all kinds, from the primitive granite to the uppermost formation of chalk. The secondary formation of flat rocks affords the most useful articles, as the beds are flat and horizontal, and are traversed by seams and fissures, which very much facilitate the excavation of the stones. Sandstones and limestones are the best rocks for making walls; and the varieties are many, and the qualities discordant. They are certainly inferior to the crystalline rocks in a very long durability; but the use is more general from the facility of being raised, and formed into any shape of blocks. Limestones are of better practical value than sandstones. Building stones.

Beds of rocks that are workable, will lie on flat grounds, or in the sides of declivities. In both cases, the lowest point must be sought where to begin the excavation, and to it the water will flow and be discharged. A road must be made to lead into the opening from the nearest approach of the common thoroughfare, of which the ascents must be easy, and the inclinations gentle. Where a permanent use of the quarry for stones is anticipated, the earthy covering must be removed and wheeled to some convenient deposition, in which no interference will be made with the future operations. If the quality allows, the earthy matters may be mixed with lime for a compost manure: at least, the uppermost stratum may suit this purpose. Where a short purpose is required in digging stones, the earth may be laid behind the operations, and thus fill up the excavation, which will again become arable ground. A depth and width of face of rock will be preserved according to the dip and inclination of the strata. When the beds sink downwards, and no outlet can be dug to vent the water, a pump must be erected to raise the liquid, and discharge it over the intervening height into a running declivity. The stones are separated and raised in blocks by sledges, picks, wedges, and hand-levers; and in case of the harder rock, gunpowder is applied to burst the rock into fragments. The nature of the rock, the direction of Working of quarries. Shaping for use.

the strata, and the lines of cleavage, adapt the modes of working to the peculiar conformations.

Quarries of stones are but little valued, except in some few cases where favourable circumstances concur to demand the use. The quality then must be very superior, the transport ready, and the sale constant and permanent. These junctions very seldom meet. When a stone quarry is worked in ordinary circumstances, the royalty varies from one-third to two-fifths of the sales, leaving two-thirds to three-fifths for the expenses and profit of the lessee. A yearly rent may be imposed, after an approximation has been learned of the probable value from the bygone practice.

Royalty.

Slates are a primary formation of rocks, crystalline, hard, and durable, and are laid in vertical strata, thin and fissile, with laminar openings. They are used for roofing houses and are very extensively quarried in Wales, and in the west of Scotland. The larger rocks are parted by wedges and levers, and the fragments by hand tools into smaller sizes. Slates are only found in the primary districts, and are wrought on a royalty, as may be due to the demand.

Slates.

Flagstones are used for laying pavements, private roads, and the floors of houses. The rock is found from the primary schist to the uppermost sandstone, in which formation it chiefly abounds, and constitutes a very useful article. The bed is raised in the natural divisions, which are afterward separated into use, as can be effected, The quarry is conducted as formerly described for building stones, and the royalty or yearly value is fixed in the same way. The stone is mostly siliceous, with a base of clay and sometimes with limestone.

Flagstones, wrought.

Clay is an alluvial formation that is of vast extent in some flat countries, and the presence of it can be traced from the decomposition of soft felspar in the primary rocks, to the sub-ærial deposit of fresh water alluvium, attending every formation, and contributing very largely to mark the connections that serve to exhibit the various stages of the ascending series of deposits. Argillaceous schistus is the first type of the body of clay, and from that primary rock, in the form of shale of very various qualities and conditions, clay is an accompaniment of every deposit, and a very strong indication of the increasing existence of soft materials in the structure of the globe. The first deposits of clay that are exposed to view, are very viscous and tenacious in the texture, from having been suspended in, and deposited by marine water, as is clearly indicated by the presence of the spoils of the ocean. Other beds are much more friable, having been washed by fresh water, and deposited by its agency.

Clay.

The finer clays, or those that are most pure in silica and alumina, are used in making porcelain and pottery, and the more mixed sorts are manufactured into bricks and tiles. For both purposes, the essential quality is the kneadable property, by which when moistened, the clay can be led into any shape by hand or tool. Porcelain clay is the finest; pottery is made of the second quality; and bricks and tiles pro-

Finer kinds.

ceed from the inferior qualities. The first kinds of clay are the decompositions of the older rocks, in veins or small beds, whence the substance is excavated like metals, and sent to the special manufactory. It forms a very distinct employment, and is not of great extent in Britain.

The inferior clays are mixed with other substances, from having been exposed to different combinations, and to the affections of external agencies. The foreign substances are lime, iron, manganese, potassa, and bitumen, in very different quantities and combinations, most of which substances tend to make the clay fusible. A certain degree of fusibility is required both in pottery and bricks, in order that the manufactured article may be rendered capable of resisting the absorption of moisture; and in all the natural clays, even the purest employed in the arts, the foreign bodies exist in them to the degree of producing fusion at certain temperatures.

Inferior qualities.

Very early ages of the world used vitrified or fused clay in the formation of vessels, and the use of brick as a substitute for stone in building seems to have had a very early date.

Clay that is fit for bricks is found in many parts of Britain: it must be free of stones, plastic, and capable of forming a stiff paste with water. Lime is added to some clays to produce a tendency to fusion, and is used as powdered chalk, or marl. Sand also is used for the purpose of preventing too great a contraction of the clay in the furnace, and it must be as siliceous as possible. The quantity is soon determined by experience, and must not make the bricks brittle. The best clays are those which already contain the portions of lime and sand that are necessary for the above purposes. Coal cinders are added to clay, and prevent the contraction of clay in burning, in the same manner as sand; the iron of the clay is de-oxidised, and the bricks are yellow, a colour which is valued in building, and the durability is increased. Certain clays resist high temperatures, and constitute fire bricks, as the constituent matters exist in some definite proportion. This clay is scarce, and is chiefly found in the shales of the coal formation.

Clay for bricks.

The beds of manufactured clay are several feet thick, or lie in very irregular deposits. In certain cases, it is dug and used at once; but most generally and beneficially, it is raised from the bed or clay pit, laid in shallow heaps before winter and in quantity enough for the work of one year. The harder matters will be reduced by exposure to the air, the parts will be blended together, and the whole mass will be mollified. In most cases, one winter's exposure will prepare the clay; but in some instances, two, and sometimes three, are required; and in all cases, a long exposure is beneficial. The clay is several times turned over and moistened with water, and if sand or lime be required, this is the best stage of the process for mixing them intimately with the clay. Straw or turf is frequently laid over the clay after being prepared in this way. Soil and stones are carefully removed when the clay is moved from the bed.

Digging.

The clay mill or pug mill next cuts the clay into minute shreds, as it

passes downwards through the action of arms and knives, which are impelled by the power of horses or steam. The clay is then ready for being

Working.

moulded into any shape, either by manual labour, or by machinery. The clay is thrown with some force into the mould, smoothed over the top by a ruler of wood, which compresses the clay, and fits it to the mould. This is the mould for flat articles; for bended and arched purposes, a slice of clay is fitted over the mould, and pressed down upon it: the moulds being removed, the shaped clay is placed on the shelves of a drying shed. An expert moulder will form 5000 bricks in a

Drying.

day, and 1500 to 2000 draining tiles. Bricks for drying are built in walls with alternate interstices, which allow the circulation of air: but for drying tiles, shelves are used in long sheds of various sizes, as the extent of works may require. An ordinary work will need a shed of 150 feet long, 18 feet wide, and 6 feet high. The sides of the shed are hung with canvas cloth, which is run up on rollers, when the screen is not wanted to prevent the effects of frost. The roofing may be of slates, tiles, thatch, or boards, as the climate may require.

The tiles must remain in the shed till sufficiently dry to bear the heat of the kiln. This time will vary from four to eight days, according as the weather may be dry or moist. Baking kilns are of two kinds; clamps for preparing common bricks, and close kilns which harden tiles for roofing and draining. The clamp is an oblong heap of bricks placed above each

Burning.

other longitudinally and transversely, leaving intervals for the passage of the air: fuel chambers are formed on the ground of fire-bricks, entering from the opposite sides of the heap: from these flues, cross ones are carried at right angles into the intervening spaces. The fuel is put into the chambers, ignited, and the clamp is gradually heated from the bottom upwards. More or less fuel, and the enlarging or diminishing the orifices of the fire-places, will regulate the combustion, which is slow at first, and gradually increased to the required intensity, and after a suitable time, the furnaces are closed, the fires extinguished, and the bricks allowed to cool.

The close kilns act upon the same principle, and the heat being confined within walls, can be raised to a greater intensity by an equal expen-

Kilns.

diture of fuel. An oblong building with a set of fuel chambers along the sides, which are prolonged into flues, contains the tiles placed interstitially from the bottom to the arched roof, and best when set on end. Cross flues of fire-bricks convey the heat uniformly over the extent, and the vapour or heated air escapes at the top by vents for the special purpose. The fire is put into the chambers, and the heat ascending warms, dries, and bakes the tiles of clay, by the rising current of air, and by the contact of the tiles with one another. The slow fire is gradually increased, and kept burning till the tiles are baked, which will require about seventy-two hours, according to the construction of the kiln, and the degree of heat maintained. When the tiles are baked, the fires are extinguished, and the mass is allowed to cool. Different constructions and

operations are used in making kilns which are more or less perfect, and may yet be much improved.

Draining tiles are now mostly made by machines, of which the most approved are those of Mr. Anislie and Mr. Etheredge. The clay passes between rollers, and hence into apertures which contain the mould that is wished, and from which the clay comes in the shape of the intended use. Some differences exist in the construction of the machines, but the purpose is effected as above mentioned. It is doubtful if any advantage is gained by the use of machinery in this respect. The article is not so well manufactured, and cheapness never can constitute true economy. For draining tiles a good article is essential, as the damage is removed from view, and is placed beyond repair. An insufficient preparation is beyond all other things to be avoided. Tiles.

The manufacture of bricks, in Britain, exceeds fifteen hundred millions yearly. The production in England, and the economy of labour exceed all other countries, but not the quality of the article, being inferior to Holland. Brick grounds are rendered useless by the digging of clay for any future application, at least for a long period of time; and the land may be sold for that use, a lease granted for a certain extent of ground, or a royalty claimed on a specific number of manufactured articles. Quantity. Rent.

CHAPTER X.

EXPENSES OF AN ESTATE—REGULATIONS OF DISBURSEMENTS—AND RELATION OF THE APPROPRIATE EXPENDITURES.

It is a fixed law of nature that all bodies tend to change condition, which terminates in a total decay and disappearance from a state of being. This tendency exists in all formations, whether organic or devoid of functional progressions; and is quick or slow, according as the natural constitution may be soft and pervious, or compact, hard, and durable. Inorganic bodies are slow in decay, but are liable to a disintegration of the parts, which impairs the quality and defeats the purpose of use. Vegetable bodies are quicker to decompose from the greater number of component parts, and the natural quality of the different kinds that are produced. Slow growths are the most durable, as the parts are more exposed in the congregation, and hardened by the external influences of affection. The inorganic creation does not allow these circumstances, and the condition is less changeable, but still liable to nature's general law. Expenditure on a landed estate.

When these materials are used for the purposes of utility, the best quality that can be procured is chosen for the special appli- Materials for repairs.

cation, and adapted as the most experienced knowledge is able to direct.

For the building of houses and walls of any kind, stones are preferred to bricks, in all cases where the former materials can be got within the bounds of a reasonable expense. But in alluvial countries, and where the distance of carriage and other circumstances render difficult the provision of stones, the use of bricks is adopted; and being an artificial production, that material for walls becomes more easily decomposed, especially if the clay be indifferent in quality, and the manufacture into bricks has been improperly executed. Not only the getting of these materials forms a chief consideration, but the quality as to fitness and durability must constitute a very large item in the estimate that is being made of any undertaking that requires the use of the materials. Expense being equal, or so nearly balanced, as that the superior eligibility of stones is able to cover the difference, no hesitation can happen which of the articles will be used; and a consideration may be added of the extended superiority which the harder material will evince beyond the present calculation of the applied utility. Where the cost of stones does not exceed fifty per cent. more than bricks, the choice will be justified of the rocky body, as the durability will recompense the surplus in requiring less repairs, and in constituting a better erection in every point of view. But where the balance of cost amounts to nearly one hundred per cent., the brick must be chosen, as that amount may never be repaid during a long currency of the necessary repairs. If the stone be sandy, and belong to the soft deposit of rocks, the decay will soon commence; exposure very much affects earthy aggregations that have not been removed beyond the influence of its power by the force of fire or a very minute cement. This quality is soon determined by experience, and has a very large effect in determining the eligibility of building materials, as the choice may happen in different localities. Bricks must be calculated in the same way, not only in the primary cost, but in a strict relation of the future value, as shown in the quality of duration. This attachment to any article will very much adjust the equilibrium against a greater original expense of purchase.

Stones and bricks.

Sandstones.

The use of timbers is regulated by the same rules of consideration as the choice of stones and bricks. The hard woods are used for purposes that are exposed to external actions which promote decay, and the softer qualities are adapted for use in situations that are covered from damage, and sheltered from violence. The timber roofing of houses being covered from exposure, is constructed of firs, which, being kept dry, are nearly equal to the hard woods. Timbers kept in one state, wet or dry, will last long; it is the change of conditions, from wet to dry, and from dry to wet, that tries the constitution of the timber, and which marks the quality of quick and soft decay. Friction, or the attriting contact of other bodies, in constant or frequent applications, imposes on timber the special adaptation of purposes, as it requires a quality similar to that which resists decay. All posts sunk into the ground are required to

Timbers.

be of hard timbers, and very much of the inside furniture of barns, stables, and cow-sheds, and also of cottages and dwelling houses. In all cases of exposure, or a more frequent use, hardness must be applied, and the best quality of it selected. Decays and repairs.

Reason and conventional agreement have established the relation betwixt landlord and tenant, or the permanent and temporary occupier of the soil, that the former affords the raw materials with which to uphold the decays of nature, and the farmer puts the articles into form, and places the adaptations into use; and also that general decays, or a universal failure of any permanent articles, are wholly replaced by the landlord; the farmer doing such a part of the work as the agreement has understood, or a posterior arrangement may dictate. But for the purpose of restoring and upholding all the small decays and tendencies to damage that may occur during the lease, the farmer gets, without price, from the owner of the soil, felled timber, lime, stones, and bricks, at the respective places of manufacture, which are carried to the required uses and timeously applied. On a neglected estate, where decays and dilapidations have been allowed to progress, and to escape observation and attention, this expense to the landlord will amount to a sum; but under all correct and systematic management, the item will be trifling, except it may be for once in ten or fifteen years, when a wholly new erection of buildings, or some part of a farmery becomes necessary; then a due allowance must be made by scattering the special sum expended on that point over the lease of the farm, and distributing it on the general outlay. A notice of it must be taken before and after the event, and by contracting the outlay of some years, prevent the expenditure of the special year from exceeding the average of the general arrangement. In this way an equitable distribution is created and maintained. Total dilapidations.

The upholding and restoring of decays of perishable materials, includes the preservation and restoring of watercourses and beds of rivers, the repairing of roads, the repairing of very old fences, or the making a new one in its place, and all purposes of repair in which any wholly new undertaking is not performed. Such expenses will inevitably occur in every case of using the surface of the earth, and the more vigilantly the wants are noticed and supplied, the expense will be less, and the general benefit will be greater. The very beginning of a want must be checked, that it may not grow into a gap of wide dimensions, in which more means may be spent than would have repaired many beginnings. These things require an active and vigilant superintendence, and a prompt and spirited execution. General repairs.

Circumstances of locality and special position will very much influence the amount of expenditure that may be required for the purpose of upholding in current-going order of a proper and sound condition all the articles of decay which a landed estate will present to that department. The size of the farms, in being small or large, will affect the cost of the repairs of houses; the intersection of the estate by brooks or rivers will require a greater or less expense, as the courses are few or many, Prompt execution.

and the roads are sometimes so arranged as to make a sum of some magnitude in the upholding. Very much will depend on the activity of management that is displayed, and the orderly system that is adopted in the vigilance of detection, and the promptitude of supplying the incipient deficiencies that may occur. The economy of this management consists not in withholding the outlay that is necessarily required in order to save expense, but in doing promptly what must be done in due time and in the proper place. No greater fault than neglect can occur in the management of business, especially when the growth of the evil proceeds increasing as time progresses.

Per centage of cost.

In all ordinary cases of circumstantial attachments, and where a tolerable exact system of management has been adopted and prevailed for some time, the sum of five per cent on the rental of the estate is found sufficient to uphold the retrograding condition that attends the articles of use in realizing the value of the ground. But where a dilapidated condition has been allowed, and where local circumstances demand a corresponding attention, a variation rises to ten per cent., denoting an average of seven or eight in cases of the medium circumstances of attachment and position. If a sum near to ten per cent. be required for a time, it may soon be reduced by a vigilant attention and enlightened system of management; and if that figure be exceeded by reason of some previous negligence, the extent may soon be curtailed within that sum; and the better way may be not to exceed it in any case, but to proceed gradually, and accomplish yearly what can be done with that amount of money, always executing in the first place the most necessary requirements. This mode may answer better than to make a very large expenditure in one year, and do nothing in the next, except when imperative circumstances require such a course of proceedings as has happened, and no doubt will again occur. In these cases, the average expenditure must be regulated by the

In a course of years.

course of five years; beyond which time no extra amount beyond the allowed medium should be carried forward to embarrass the next period of that amount of years. Each year must be kept as nearly as possible to the sum that is allowed and fixed for the special purpose; and no proceedings of any kind are to be left to uncertainty where they can be fixed. Extras and accidents will require deviations which are soon ascertained by the lapse of experience, and reduced to the original regulation, and made a part of it. As was before observed, the replacing of an old erection of any kind by a new structure, falls under the department of upholding the decays, for a similar thing stood there before, whereas a new erection understands that nothing of the kind had ever before appeared.

New undertakings.

The execution of wholly new undertakings on a landed estate deserves a consideration that is widely different from the repairs that are required to uphold the value that is being derived. That department of outlay admits no dispute, it only needs a regulated disposal. Original executions will be various: in making new roads, new plantations of trees, cutting watercourses, or new beds for rivers, consolidating farms, and erection of dwelling-houses for tradesmen and mechanics—these

objects require a very careful and attentive consideration of the concomitant and combining circumstances which may seem to justify the execution.

It must be very readily granted that all grounds that cannot be ploughed, or any way improved, and which do not yield a natural pasturage of some little value, should be planted with trees, as a crop of timber may be got of some degree of quality, and the land is improved for the future arable cultivation, if wished to be restored, and if the surface formation will allow the use of the ground for the use of aration. If water can be conveyed to irrigate the surface, the value may be well used in that way; or if the ground can be improved by a top-dressing with composts, the planting with trees may not be eligible. But precipitous grounds, rocky declivities, and slopes that are beyond practical use, do not admit one moment's hesitation in being converted into a plantation of timber or copse wood, according as the nature of the ground and the demand of the locality may direct. A coppice will return a value in eight or ten years, when the circumstances are mediately favourable, and at most in fourteen years, when the best use of the growths requires a lengthened duration to attain the necessary maturity. The quickest return in value from timber trees comes in about thirty years from the fir tribe of plants: the hard timbers will require a period of nearly sixty years before any part of the expense is returned which has been incurred. During that time the outlay lies dormant at compound interest, and in sixty years will be quadrupled in amount, and doubled in thirty years. All these considerations must be duly and very carefully weighed in estimating the propriety of an undertaking in planting trees, and discover if the use of money could not be more beneficial in some other expenditure. But many situations will occur where no other use of the ground can be devised, or is rationally possible, and then the calculation comes to be the extent to which the execution may proceed at one time, or at distant intervals. A large performance may throw a burden on the property that is too heavy for its position, and the improvement may be too extensive to form a proportionate part of the aggregated extent. The amount must be duly regulated by the circumstances of the proprietor, and the capital that can be spared to the purpose of general improvements. A certain quantity of money should be allowed for this special purpose, in all cases where the requirements are in existence; and but few situations are found where the wants do not happen. New plantations are not by any means to be included in the charge of five to ten per cent. for the purpose of upholding the current-going value of landed property; that allowance only supports a value, and does not create any source of deriving an income. All creations that are wholly new, are to be entered in an account that is altogether disconnected with any other rendition, the outlay is sunk for many years, and a heavy interest charge comes against the proceeds that may be realized. It is true, that a trifling expense is incurred yearly in carrying forward the increase of plantations, in keeping clear the courses of water, and maintaining the fencible condition of the boundary walls. This balance, though small, assists in ren-

Waste grounds.

Plantations.

New things special

and distinct.

dering more tolerable the long period of time during which no value is derived from plantations of trees.

It may be again observed, that all grounds that are physically beyond any other purpose of application, cannot be too soon planted with trees, in timber or copses, which may be very beneficially mixed in the position of enclosures, but not in the plants being placed in mixture. There is no doubt that loans of money now granted by government to drain wet lands will soon be extended to the two purposes of erecting farm buildings and planting waste grounds, and both uses are fully as necessary as the removal of superabundant water; and no more just and beneficial burden can be imposed on landed property than the performance of these three purposes, which increase the quantity of the necessaries of life, salubrify the air, add to the lasting value of the property as an article of commerce, encourage the letting of it for temporary use, shelter the country, adorn the scenery, and contribute in a variety of ways to the comforts of the people.

Loans of money used in three ways—draining, planting, and building.

The raising of new embankments, and the cutting of water-courses in an original direction, forms another item of general expenditure to be charged to the account of improvements. The return arises from the estimated advantage that will accrue from the performance in a larger abundance of some articles in a certain quarter than would have been produced or were grown if the new work had not been done. This calculation must go beyond a barely ideal existence if at all possible to be attained; the accruements must be clearly obvious, and almost firmly tangible, in order to justify the expenditure on points that require to show certainties in the returns. These executions require a yearly charge in upholding the useful condition, and consequently, the inducements of performance must be stronger on that account than where one action suffices for a long period of time. These occasional or probably constant repairs are included in the charge of upholding the current revenue of the property, and must be put under the regulation that apportions the yearly amount of that expenditure. The cutting a river course may be divided by two parties that possess the opposite sides of the river, and will be mutually benefited by the alteration, when each side of the banks will be defended by the proprietor, and the cost included in the charge of yearly repairs. The building of new jetties of stone works, in order to throw the course of waters into a mid-channel, and save the banks from being wasted, will go to the charge of upholding, as the want of the article may incur a much greater outlay in erecting the same protection after an extensive evil has been done. These structures for the purpose of preventing future evils that may be of a great, but are still of an uncertain magnitude, differ from the requirements that are needed for the purpose of warding off constant occurrences, as floods of water and rise of tides; the latter operation being once done, the repetition is unnecessary; in the former case, the uncertainty of coming storms renders a constant employment in the protection of the alluvial banks. Such employments are to be added to the account of protections, as distinguished from total alterations,

Extra purposes.

Rivers.

which first confer a benefit, and then require a yearly charge to enable the continuance.

Roads

The making and maintenance of roads does not in every case form a separate charge on landed property. The turnpike roads are managed by commissioners, who need no local assistance: the public roads of local use are, or intended to be, supported by a fixed charge on the rental of each farm, which is to this day, in most places, badly arranged, and imperfectly executed. But when a new road is formed, or an old one reconstructed, the proprietor of the land is always expected to bear a chief part of the expense; when the item must be charged to an expenditure for which no value may ever be got, but an improved passage of use, and a benefit conferred on the public at large. It would be a very superior arrangement that all the roads on any estate of land be managed by the chief direction of the agent on the property, and the acting power delegated by him to a subordinate in office under his surveillance. In that case, the whole expense would fall on the landlord and the farmers; the latter bearing the one-half of the expenditure, and the other moiety attaching to the owner. This outlay on the property must be charged to the yearly per centage of use, as it goes to uphold the current value of the property in the provision of roads, which form the first consideration in the lasting improvements in any country or division of territory. Another arrangement will charge the land-owner with making all the roads, and that the farmers uphold them; but most of the necessary roads are now made in Britain, and the landlord would escape the fair contribution. But where new roads are required, the owner must bear the original outlay, and also the future share of the necessary repairs. The charge made on the rent of each farm for the purpose of roads, will be paid to the agent at the half-yearly audits of rent. The mode is used in some few instances of the roads being managed by the estate agent, and the benefits are very evident and frankly acknowledged. The farmers being only temporary occupiers of the ground, no part of their funds must be applied to the structure of permanent erections; the land-owner is the liable person, and also for a fair share of the future requirements to uphold the value. The landlord gives a share in upholding buildings on a farm by giving raw materials in lime, stone, and timber; so in upholding roads, after his cost has made them, a share must come from his property to maintain the articles in use. This charge, where it is come into use, will be included in the per centage of repairs.

under the agent's care.

A beneficial arrangement.

Bridges.

The building of bridges is generally a private concern of the land-owner, or of subscription among the neighbouring proprietors, when the possession of it evidently assists their advantage. At all events, such a thing is wholly beyond the province of the farmer, and it is also removed beyond the charge of repairs: it is an original edifice, and needs no future amendments that can form a charge. The owner of the property is always expected to make the largest contribution, and very justly in many cases, as his property will be most largely benefited by the erection. But instances are not wanting where the public will be

equally, if not more, advantaged than the property itself by the projected means of traffic, when the owner of the soil may be allowed an equality with other subscribers. If any landed property does not exist on both sides of the bridge, the advantages are not so large to the benefit of the patrimony; the bridge is only a public transit through the estate; but when both sides belong to the same property, it is a means of communication, and becomes doubly valuable. All these considerations occur in estimating every kind of outlay on the estate of land; the private advantage to the owner, the general benefit to the country, the charge required to derive undiminished the current-going yearly revenue, the amount that can be allowed to general improvements which promise a distant return, and what sums the extent and value of the property are able to give in extras, as contributions and subscriptions, for objects of public utility.

Singly or doubly useful

It is an important point to fix the relation of the several points of expenditure on an estate of landed property, or the respective amount of the items which constitute the gross outlay over the whole extent. For this purpose it is necessary to ascertain the most valuable points of outlay, or those which return the quickest value for the money that is expended, and the steadiness of the source which forms the spring of revenue. Two items constitute the chief outlay on landed property—farms and the plantations. The last point is contained in two departments, or the making of plantations, and the cost of protecting those that have been made, dividing the outlay into two accounts, which must not be confounded together, but separately arranged; the two amounts being added together will show the gross outlay in the department of plantations. The growing of timber makes slow returns, and at distant periods of time; the thinnings, if any, consist of worthless under-growths, which fetch little money, and do not repay any part of the original cost, if the value upholds the current item of expense. But on most estates, a quantity of timber will be found that is full grown and ready for sale, and by a certain quantity of yearly value from that source, the current-going expense will be covered, and a surplus be derived for the rent of the land. When oak timber is produced, a double chance occurs in the wood and bark as articles of value, in obtaining a revenue from the plantations, which contributes very much to the value of the grounds. A yearly fall of timber is to be recommended in all cases where the articles are found; if not yearly, then in the time of two or three years, a sum of money, less or more, must be got from that use of the land. The regulation is imperative, that on all estates which contain woods of the proper age, an income be derived from the sales of timber which shall cover the cost of upholding, and if possible, a surplus be accumulated that will defray the expense of making new plantations, in some part, if not the whole of the outlay. From the revenue of the plantations a per centage must be deducted for the current-going expenditure, which will not be large, but still forming an item. The very varying conditions of estates of land in quantity and quality of timber, and the uncertainty of

Purposes of outlay.

Woods.

Revenue from them.

the value of the article, render impossible any nomination of the amount of the per centage; the sale being large or small, adds to the difficulty, and the figure must be left to the circumstances of each particular case that occurs. Where no timber exists that can be sold, then the cost falls upon the rental of the estate, when the average per centage for the purpose of plantations will not exceed two to three per cent., or about one-third of the cost in upholding the current value of the farmed lands; and it will require an estate of some magnitude, and woods of very considerable extent, to use that allowance, except in cases of making alterations and improvements beyond the currency of procedure. In this calculation there are not included the timber of pleasure grounds, or of parks and policies; these places are isolated from common touch, and are not depended on by any estimate of value. All hedge-row timbers over the estate are contained in the calculation, and the same purposes of use are attached. Copse woods, if any, are comprehended in the account, and ranked with timbers in the general estimate.

None but an outlay.

On estates of old improvement that are proportionately wooded and enclosed, a yearly rental should be derived from the produce sold, or at least the current expenses should be paid by the article which requires the protection of cost. Cases will occur of under-age plantations, when no value can be got, but must be waited for till the timber is matured for use. A yearly item will then be expended in the protection of the plantations, which will vary with the many circumstances of extent of grounds, situation, locality of the fields, and the exposure of situation.

Young plantations.

The yearly revenue that is steadily derived from the lands that are let in farms of temporary occupation, requires an attention much wider than that of plantations, and a larger allowance in proportion to the value of the source of income. The produce of land being yearly in its nature, the value is annually derived; and as the recurrence is steady, and not liable to any omissions, the more attention is required that no wants be allowed which may impair the yearly revenue in the necessary attachments. Plantations are in general an improving department, at least to a certain age; the appurtenances of a farm are decaying from the very day of erection, and demand the care of upholding in order to continue the income that is got from their use. This very essential difference renders necessary a much larger allowance for the support of the most valuable department, and as it constitutes the chief part of the property, it must be first considered, and have the proper estimation. A per centage on the gross rental of the estate in five per cent. has been found sufficient in cases of well-regulated estates, and of business judiciously administered, where former carelessness creates no large demands, and fortuitous circumstances have no large possession. A variation to ten per cent. has been allowed to meet the cases of extraordinary demand that arise from natural causes, and from the bad administration of former officials, or from some undefinable or incontrollable cause which may have ceased after a time, and then the work of regeneration must commence.

Rent of lands

Per centage to uphold the value.

But these extremes of extra charge are not to be included as common demands, and should be noticed as examples to be avoided rather than models of imitation. Few or no cases should reach the medium figure of seven and a half per cent., which shows an outlay beyond the justness of good regulations and a sound apportionment. At the same time, few or no estates will need less than five per cent., unless a niggardly parsimony be allowed to exercise its sway, and create many wants to demand on some future day an expenditure much beyond the amount of savings which it is able to show at the present time. This policy but too often prevails, and is attended with much loss and inconvenience.

Not to be exceeded.

By taking seven and a half per cent. as the average allowance for upholding an estate, and the cost of the plantations at one-third of that sum, there is got the figure of ten per cent. as the amount of these two expenditures on landed property.

Cost of gardens, policies and pleasure grounds.

Gardens, policies, and pleasure grounds, form a part of the appropriated use of an estate of land, and require a proportionate allowance for the maintenance. These establishments form an article of luxury rather than use, and no tangible revenue is derived from them; yet a burden is created on the landed estate, and a consideration is due to the department when the parts of any estate of land are regulated in calculation. Plantations make a return in some annual sums, or in more years' amount, or a large value is obtained from a general fall of grown timber, which must be distributed over the years in which no income was derived. But gardens and reserve grounds never show a return of any value; the whole produce disappears, and the cost of production must come from another source, or the rental of the property. The extent of these appropriations will depend on the extent of the property, the family of the owner, and if the domestics are constantly resident; but in general cases, a per centage of two and a half per cent. will suffice for a genteel and moderate establishment, where prudence and economy are duly entertained. Thus, two and a half per cent., added to ten per cent., as shown before, makes twelve and a half per cent. for the current-going yearly cost of supporting the yearly value of a landed estate, and allowing two and a half per cent. for extras in contributions and subscriptions for purposes connected with the property, there is got the sum of fifteen per cent., as the gross estimate of maintaining a landed estate. The average may be stated at ten to fifteen per cent.

Whole per centage.

CHAPTER XI.

VALUATION OF LANDED PROPERTY; OF THE SOIL, OF HOUSES, OF WOODS, OF MINERALS, OF MANORIAL RIGHTS, OF ROYALTIES, AND OF FEE FARM RENTS*.

Land having become an article of commerce is raised and depressed in value by the same laws and contingencies as other commodities that are used for profit and advantage. The value of a landed estate, as the subject of sale or purchase, is primarily determined by the free rent which is produced from the use of it. This rent may be calculated from certain assumed rates of farm produce—but the simple determination proceeds from the marketable value of the land, or the amount which can be got for it by the farmers of occupation.

Land how valued.

The probable rent is diminished by all the burdens which affect the land, as land-tax, poor's rates, tythes, and any other burdens which fall upon the land, and not upon any other securities. The net rent thus obtained, is to be multiplied by such a number of years' purchase as land produces at the time in the market. This expression shows the amount of interest which the buyer calculates upon receiving from his purchase-money. Thus, if the number is twenty-five, or if the purchaser pays twenty-five for every £1 of free rent, being in common language twenty-five years' purchase he will receive four per cent. for

Interest of purchase.

$$25 : 1 :: 100 : 4.$$

If the market price be three years' purchase, he will receive three and one-third per cent. for

$$30 : 1 :: 100 : 3\tfrac{1}{3}.$$

The common rate of interest should determine the number of years' purchase; but the demand for land, as compared with other securities exerts the same influence, as in all other cases of transactions in selling property.

When the sum of five per cent. constituted the rate of interest in this country, the common calculation reckoned land to sell at twenty-five years' purchase, or, in other words, that it should yield four per cent. of interest. But this proportion is not now upheld by land—the market rate of interest scarcely exceeds three per cent., and land is sold at prices which does not even reach that figure.

When it is wished or fixed to have a certain rate of interest from land, the number of years that will yield the amount being multiplied into the net rental, the product will exhibit the amount of the purchase-money, which must be increased by the estimate of woods, mines, or other adjuncts, and diminished by all incumbrances that may exist. The present value must be ascertained, as in the case of annuities, and the amount deducted. An annuity of £100 yearly for ten years,

Per centage expected.

* See also examples of practice, pp. 620–631.

payable half-yearly, and at the rate of three and a half per cent. interest, is worth £837 12*s*. 10*d*. to be deducted, and so on with all similar cases.

Leases of much consideration.

A heavy consideration is due to the leases of land, if the rents seem equitable, or low, that no advantage may be expected, when the holdings expire, or that a rise of rental is evident. Leases which are long in expiry are generally reckoned adverse to the selling of land, as the chance is distant of deriving any advantage that may occur. But no large calculation can be founded on these probabilities, which are at best uncertainties, unless the rental be very palpably under the average of the common estimate. In that case, and where several cases are found, an inducement may be formed to advance the offer of purchase, as a realization is evident of the increased amount. Farms that are underlet, and which are held by lease, constitute an annuity in the amount of the yearly deficiency, and the same thing as if the money was paid to a recipient quarter, instead of not receiving it from a source of proper value. If a farm have ten years of lease unexpired, and the rent be evidently £100 too low, then the sum of £837 12*s* 10*d*. is to be deducted from the purchase-money which was shown before to be the present value of £100 for ten years paid half-yearly, and reckoning interest at three and a half per cent. These deficiencies on the wants of the realized value, are encumbrances upon the property, and tell heavily against the market value of land. But such cases do not often occur, as values of every kind have now been well ascertained, and in a period of time and under circumstances which exclude the rational expectation of any great change.

Encumbrances.

Condition of the estate

The general condition of an estate of land will very largely influence the amount of the value, in its being forward in condition, well regulated, and under the due administration. If the appurtenances of the farms show extensive dilapidations, and will immediately require a large outlay of money to execute the necessary repairs; if the roads show an incommodious condition, and need any considerable restoration; if the plantations exhibit a state of neglect, are open and exposed to depredations; and if the fences are broken down, damaged, and misthriven, too few in number, and ineffectual in the purpose, a very large drawback will be formed by the aggregation of such items, and the money that has been saved by the parsimony of neglect, will now be deducted in a greater sum from the expected amount of sale. Articles that are exposed to view for the purpose of vendition, must be exhibited in the very soundest possible condition, as the flaws are the objects of observation, and are always magnified rather than lessened, or even fairly estimated. A hurried preparation does not exhibit the proper and necessary train of enticing appearances, that are necessary to secure an approbation of willing investment: the newly raised exhibitions are seen through, and raise a suspicion of other coverings being purposely used. Only a long and continuously persevered administration of care and economy, can exhibit a landed property to the eye of purchase in the garb that will both suit the fancy and please the judgment: show an article

must be sound and pleasurable.

for the delight of the mind, as well as profit to the pocket. In making these preparations, it is only necessary to consult the current condition, in articles of lasting utility, and of durable pleasure. These purposes suit both views, of present possession and of future dismemberment.

Houses paying rent.

Many, or nearly all estates of land that are of any considerable extent, possess houses that pay rent, either in single tenements, or in congregated villages. The property is more perishable than the land which is cultivated, and repairs are regularly required to support the tenantable condition. The per centage on the rent of houses to uphold decays, is to be deducted from the yearly amount: but it is generally included in the general per centage over the estate, and is not separated in a distinct account, except the village be large, and yields a revenue that deserves a classified consideration. In that case, a distinct view is shown of the different values got from land and houses—the expense of maintaining the serviceable condition of each species of property, and the net revenue from each source, when the purchase cost can be distinguished. The decaying nature of houses requires a larger interest than lands, and consequently a smaller number of years' purchase. The interest being calculated at seven and a half per cent. in the common estimate, the number of years will be about thirteen and a half on the purchase number. The general number is below that figure, and falls even so low as one-third of the calculation in diminution.

Villages

In many situations, houses pay a very encouraging rent of a property in land. In manufacturing districts, in convenient fishing stations on the sea coast, and in places where mechanics abound, the erection of cottage dwellings becomes a good outlay of money—the rents are small, and easily raised, and are generally well paid. The source of employment and the means must be first discovered, and the permanency of the undertakings. When these provisions exist in a moderate degree, no more beneficial ornament can be conferred on a landed property than a number of conveniently located and suitably provided cottage dwellings, showing health and contentment, and nursing the bonds of union, and the sinews of the nation's strength. All such habitations must be under the management of the landlord, and not placed under the dominion of any farmer, except where the domiciles answer the express purpose of lodging the labourers of the farm. In that case, the property ranks as a provision of the farm, and is merged into the value of that department. In sequestered localities that are removed from the conveniences of the parish village, and where farms of land are regularly constituted, it would be very advantageous and beneficial to establish a village by the means of the proprietor, import the raw materials, export the produce, employ labour, and circulate money. A value would be given to the property, and if circumstances are moderately favourable, the adverse ones may be turned into sources of nutrition.

not the farmer's care.

The foregoing remarks only apply to houses that yield a rent, or are capable of yielding a revenue, and not all to the houses of the farm, which instead of being placed to the value of the land in the proper number, are to

Separate woods.

be deducted from the purchase-money, when they are seen to be deficient in the necessary provision. The amount that may be estimated to erect the required habitations must be deducted from the number of years' purchase.

Woods are determined in value on several data: full-grown timbers are estimated by the selling price, lessened by the cost of felling, and the expenses of sale. The improved condition of the land may be reckoned, when an arable state of the ground is intended to be done; but it is mostly replanted with young trees. A calculation can be formed of the number of trees on an acre of ground, and local experience will be able to form a value of the single trees, and thence of the acre, and of the total number of acres in the plantation. It is best that the seller has the trees felled by his own workmen; and in some cases, an eligibility may occur, that the trees be dragged outside the wood by the same employment; but if this last performance be not done by the seller's execution, the felling of the trees is very properly done by that part of the transaction. Distinctive marks separate the trees, so that no confusion happens. Lots of bulk to suit a variety of purchase, may be laid outside the wood, and sold in divisions, or by the measured foot. And as before observed, it is much best, that the owner has the trees brought to that position, and that no purchaser enters the plantation.

Young plantations.

When woods are not full grown, but vary in age from the year of being planted to the time of maturation, a different mode of valuation must be adopted. The cost of producing woods is usually applied as a mode of valuing young trees, and when the age of timbers approaches the full growth of use, the value of the wood when felled may be learned from the knowledge of the value of timber, and the corresponding deduction must be made in the number of years that will elapse till the maturity be attained. The land will be improved for the purpose of pasturage; and this consideration may form an item of some value in the estimate. The amount of the original expense of forming a plantation is increased by the accumulated interest from the time of outlay to the time of sale, the amount of the annual rents, with interest from the period of planting to the time of sale, and the value of the land on which the wood is growing, because the cost of the land on which the wood is planted, is part of the cost of production.

Valuation.

If land worth 10*s.* an acre has been planted with trees for twenty years, at £5 an acre of original cost, the value of the timber in this way will be as under:—

	£.	*s.*	*d.*
The sum of £5 principal and interest at 3½ per cent for twenty years	9	19	0
The amount of 10*s.* per annum at the same interest and time	14	2	10
The value of the land at 10*s.* an acre, at thirty years' purchase	15	0	0
Value of the wood in twentieth year, per acre . .	39	1	10

This mode of valuing woods is not eligible, unless the age of the trees

be very young, or under ten years, when the approximation can be better made from the existing circumstances than from the distant value of the matured article. The calculation only shows what the cost has been to the seller of the land to bring into the present condition the article which is offered for sale; but it affords no index to the value of the materials after the lapse of many years, during which time the purchaser gets no revenue, and has to wait the expected return. The age of thirty years will bring to maturity the general average of plantations of fir trees, and sixty years may be allowed for the use of the hard woods, as oak, ash, and elms. In unmixed congregations of trees, the calculation will be based on these simple periods of time; but where the woods are of mixed kinds, an opinion must be formed of the relative quantities of each sort, and then assume an average number of years in which the maturity will be reached. This assumption may be forty-five years, which may be divided into three periods: 1, of simple growth; 2, of accelerated growth; 3, of matured growth: and each period must be attached with a definite portion of the ultimate value. The simple division of the return into three parts would not be a fair apportionment, for the trees during the first period of time will not attain anything like one-third of the matured value, and consequently a reduced item must be attached. The middle division of time will increase the most rapidly, and will push the trees to the full height, and commence the hardening of the timber into the useful consistence. The third, or last period, will bear the largest value, as the timber gradually attains the matured state. A notice must be taken of the quality of the soil to carry out the growths of the earliest periods, and of the exposure to allow the statures; for not unfrequently the first growths are encouraged by favourable circumstances which do not exist when an advanced stage of existence is attained. Observation will not fail to intrude the necessary deductions on this point.

Age of thirty years.

Three periods.

The first object is to compute the number of trees on an acre of ground, which may be averaged by observing the distance between each standard that prevails over the extent of the plantation. Then the probable value must be ascertained of the timbers when full grown, and felled for sale. The age of the plantation being known, and the time of full maturity fixed, as before explained, there may be given to the latter division of time, seven-tenths of the aggregated value of the timbers when sold, one-fifth of the same sum to the middle division of time, and one-tenth to the first fifteen years of the growth of the trees; and if the sale happens when the age is about thirty-five years, or nearly to seven or eight, then one-tenth is to be taken from the third division of the age, and added to the first apportionment. This becomes necessary, from the greater value which has been attained by the young growths in seven or eight years, than if the valuation happened at the time of three or four years; and the last stage of maturity is less in value at thirty-five years than if the calculation was made between forty and forty-five years. Besides these data, other contingencies will occur to influence the calcula-

General objects.

tions, which must be alive to every observation, and open to every suggestion.

Woods below use.

Growing woods of any age that is below the condition of immediate use seldom or never in this country realizes the full value in case of sale, being reckoned a dead stock which the proprietor cannot use, or remove, or cut down without damaging his estate in the very essential provisions of shelter and embellishment. Such acts would inflict a damage on the general value of landed property that would many times exceed the amount of any sum that may be shown by calculation, even the most correct and the most substantially founded, and hardly would any diminution of value compensate the loss or want of one of the chief ornaments of nature, as shown in clothing the earth with vegetable growths of low and high dimensions. In most cases of young woods, the plantations are generally reckoned a most necessary appendage to any extent of landed property, of which the value is scarcely entertained; but if wanting, the value would be largely accounted and urged as an abatement. The justness of the complaint cannot be denied, and urges the demand on all proprietors that the provision be not in any case neglected. The price of growing woods, however it may be estimated, resolves itself into a simple bargain, of what the seller can get for it, and on what sum the purchaser is inclined to give, after he has consulted his convenience, and has prudently weighed the combination of circumstances which occurs to justify the purchase of the property.

Price of them.

Land and wood, chief sources.

The cultivated lands and woods constitute the solid basis of landed property; the other sources of revenue are only attachments, that are evanescent in the nature, less durable in the fixity, and more exposed to chances and accidents of disruption. The chief attention must be paid to these two sources of revenue, as they form the only permanent foundation of any sound procedure. The intrinsic quality of any soil, and the value derived from it, are no doubt, the primary points of regard, as by them is fixed the sum of the revenue; but many cases will occur, where an extended view must be taken of the capabilities of the natural provisions as inducing the probability of profitable undertakings beyond the present realizations. The susceptibility of future improvements is a quality in landed property that is often more valuable than the present condition of profit, for it holds out the chances that may occur during the progress of undertakings which frequently much exceed the original calculations. The presence of woods and of dwellings on the estate are essential to its existence as a patrimonial inheritance, or a source of revenue; without them, land is only a dreary waste possessing neither shelter against the storm, or food against the natural cravings. The strength of a nation is founded on the number of its people, and an estate rests for value on the number of its appurtenances, and the state of the establishment which is maintained. The existing state or manner in which lands lie, makes all the differences imaginable in the estimates of value and produce. The situation has very great influence, being near to towns, convenient to manufactures, or con-

Susceptibility of improvement.

nected with an advancing condition of elements. The temperature of situation is also a matter of notice, as it affects very much the value both of lands and woods. The social position of an estate of land must also be considered, if the community be liberal-minded, or prejudiced, frugal in habits, or lax and dissipated. The habits of industry and of social affection must not be overlooked, and if the capable improvements of the district be fully performed, or are only being commenced, or half-way progressed. In a case of large improvements being done, the supply of labour, and the demand for produce will be taken into account, and the conveniencies that are seen of making these provisions, as is possible in many cases, where the necessity may dictate. The probability of creating a revenue, as well as the certainty of getting an income ready-made, will weigh the scale of judgment in the ratio of the considerations that are brought to bear upon the subject, and a greater number of these items occur in the purchase and value of landed property than in most other human transactions. The seller must be aware of the circumstances that will bring forward these considerations, and have the articles for sale in the best possible condition that can remove objections which act in any way to detract from the value of the commodity. Woods and buildings are the foremost of the appurtenances of landed property, and no reasonable expenditure must be withheld, in order to make the provision of these two articles, that is conformable with the property and the attending circumstances. Buildings are required to uphold the current going value of the land, and timbers are needed to construct and uphold the buildings, and both objects being artificial productions, can be raised on almost any lands in Britain. Articles of fancy and show are not required beyond the precincts of the pleasurable demesne; the provision over the estate must suit the circumstances of use, and lead to advancement. In making plantations, care is to be used that no encroachment is made on arable purposes, as the value of woods is posterior to the growing of yearly crops, which supply the daily wants of recurring use. A due proportion must be observed of the present with the future purposes, unless the grounds show a large amount of useless surfaces over cultivable lands, when the expediency admits no doubt of the speedy conversion of wastes into some shape of utility.

Social position of an estate.

Probability of a revenue.

No articles of show.

Mineral property of any kind is always reckoned a valuable appendage to an estate of land. If none of the valuable metals are found to enhance the value of the surface ground, and even coals being altogether absent, there may still exist a sufficient quantity of clay and building stones with which may be supplied the current wants of the property in the manufactured article of bricks and stones for walling. The presence of these articles, though none are sold to raise a yearly revenue, is a very large convenience to any estate of land, as it abrogates the necessity of foreign purchase, and tends to the constitution of the property as being self-contained. A self-supporting property conveys a title to eligibility, and the necessary articles being present, will form a pre-eminence

Mineral property.

over those that must be wrought for foreign use, and which have to supply the want of the materials that are constantly required. The value of these adventitious articles of property is variously affected by the ascertained continuation of the mineral substances, or the apprehended exhaustibility,

View of the articles.

the prospect of the value being maintained, and if the support of the undertaking rests upon the solid grounds of suitable accompanying provisions. If the foreign export be none, the value of coal, clay, and building stones will be very considerable; and with the total want of coal, which is the most general case, the attachment of building materials will have a due attention. The quantity and quality of surface ground, which may be destroyed for use in working the minerals, must not escape the notice of valuation; the allowance in money for the destruction will detract a something from the value in all cases where the use of the surface infers a price of any amount. The annual revenue that is derived

A mine and land of a similar value.

from a mine, is held to pay the same interest on the purchase-money as the soil of the earth, and it is liable to the same deduction in a per centage for the yearly upholding of the current going order. In some cases, this charge will exceed that of land that is let in farms, as the movements of action are quicker and more frequent, and the frictions and collisions are much more numerous of the different bodies that are in use. This consideration, the probable exhaustion of the article, and the uncertainty of demand, impose upon mineral property a cheaper purchase than of land in the full proportion of one-half the amount. The surface of the ground can be seen, examined, and estimated, and the possible and probable capabilities are estimated in prospect, the use of it can never fail while the human race exists, and all the artificial repositories of money are trifling safeguards in comparison with the improved utility of the natural patrimony. Minerals are an adjunct to it, and a very valuable one; but the use is much hidden, and the continuation

but differ in prospect.

uncertain. Hence, though the net produce of mines does add to the aggregated sum of the purchase-money of a landed estate, the reckoning must be separately made, and the entertainment different. The chief consideration rests upon the continuation of the rent at the present reported value; the extension is a matter of choice in any improvements that may be contemplated to make on the property. The probability of this object, however, will conduce to flatter the prospects of purchase, if not over-estimated by the selling party, and put forward at an extravagant estimation. A thing that may be done is of uncertain amount, as the doing of it is exposed to many contingencies that are beyond all calculation; on these points, any fixed data give way to the best assumptions.

Years of purchase in mines.

Calculating land to fetch at present twenty-four years' purchase, which may be beyond the average, except in very prime qualities of soil and circumstances, minerals may be put down at twelve years' purchase, and the net revenue being multiplied by that figure, will give the amount to be added to the proposed offer for the possession of the estate.

Manorial rights.

Manorial rights or claims exist over lands that are not enclosed, but have been left open to the purposes of different

usages. When the disruptions happened of the large congregations of landed purposes that had long existed in Britain, large tracts of ground were appropriated to general use, with reservation of certain rights to some superior person who adjoined the property, and who contemplated his own possession of it at no very distant time, by granting the use of it upon retainable conditions. Some lands were used in common pasturage that was open to the adjoining grounds of cultivation, and the lord of the manor had the mines and quarries reserved for his use. Wooded grounds yielded the pasturage to the adjoining tenants, and the growing timbers are the property of the lord; and as manors of land came originally from the crown, the lords who held them gave away to lesser lords the similar possessions, and retained the claims over them, which have been called manorial rights. Quit-rents, escheatments, and heriots were established, which yet exist in a very diminished degree. Quit-rents, or quiet-rents, is a certain small rent, payable by the tenants of manors in token of subjection, and by which the tenant goes quiet and free. It was anciently called white-rent, because paid in silver money, and differing from rent-corns. Escheatments are a fall of the land to the lord of the manor, by reason of the extinction of the blood of the tenant in the want of heirs, or by the commission of treason or felony. The original conditions being broken, the gift resulted back to the lord who gave it. Heriot is a personal chattel, due to the lord on the death of the tenant, and is no charge on the lands, but merely on the goods and chattels: the lord chooses any article that may appear good. Fines were also imposed by the higher lords upon their dependents for the alienation of the land that was given them.

Quit-rents.

Heriots.

These feudal relics are yet found in South Britain, where ancient usages drag a lengthened existence beyond the rest of the kingdom. Heriots will depend on the probable chances of human life, and on the value of the articles that can be taken. One seizure in thirty years may approximate the chance of the property, which may place the purchase in that of ten to fifteen years. It is uncertain what articles are liable, and the value cannot be named. The timber trees that grow on pastured lands are counted and valued by the age, as in the enclosed plantations; and there must be taken into account the probability of how many may succeed in growing in future years, as the young shoots are constantly exposed to browsing animals. The value does not form a large figure in the estimate of property in land.

One in thirty years.

Royalty is the claim of the crown over the mines that were wrought as its property, and was continued by the owners who succeeded as possessors. It consists of a fixed part of the value of each article that is sold by weight or measure, and was charged for the liberty to work and sell the materials. It was a prerogative of the crown, which descended to the next in power, or the owners of the soil, as they existed in titled or inferior gradations; the distinction was continued, as it implied both the profit and pride of superiority. When mines are dug and carried into a current-going condition by the landlord's expense, and the approximated value has been ascertained, a fixed yearly rent may be agreed be-

Royalty.

tween the parties; but when speculation enters upon the undertaking, a royalty on the sales constitutes the safest ground of action, and must have a lease of suitable duration to warrant the outlay. After the expiring of the first lease, which will generally fix the future value, a yearly rent may supersede the royalty, or it may be continued by mutual option.

A free rent.

A royalty is a revenue that is free of all deductions, as the costs of every kind in working and upholding the currency of action falls upon the tenant, and the landlord gets the stipulated part by the trouble of receiving it. But the exhaustible nature of the property, and the uncertainty of demand, fall equally upon both parties; and the purchase value of the owner's share is reduced to the number of twelve years in the half of property in surface ground. Royalty is the net rent, calculated posterior to the cost to the tenant of upholding materials, and therefore both ways arrive at the same value to the owner, and do not alter the amount of the purchase-money.

Fee-farm rent is a free value.

Fee-farm rents are due from tenures without homage, and which belonged to the heirs for ever. The feoffment contained very special articles of agreement, one of which was the power of the feoffer and his heirs to enter into the possession of the lands upon the rent not having been paid for two years. The rent was one-third or one-fourth of the value, and some conditions of performance were imposed, as upholding churches and chaplains; but no fealty or service was done to the superior, as it was a removal of burdens from himself, and for which he allowed a means of performance. This trifle is free of any deduction, and may be added in the yearly amount of the unincumbered rent of the land. The likings of superiority yet continue these relics, though they are now both few and unimportant.

The foregoing modes and items of valuation may be illustrated by an example of the statements that have now been given,

General valuation of an estate.

An estate of land is let into farms, which yield a gross rental of £15,000 yearly. The net-rent must be shown on which to calculate the purchase-money after the burdens have been deducted:

Gross rental	£15,000
Burdens—Allow 12½ per cent. for upholding the current-going order, as previously shown	1,875
Net rental	£13,125

Which is formed wholly from the surface ground, and is augmented by the following items:—

	Rent Yearly.
Royalty of mines, which is free of burdens	£350
Manorial rights by estimate	150
Fee-farm rents	50
	550
Surface-rents	13,125
	£13,675

	Purchase-money.
The net-rent, with the manorial rights and fee-farm rents, is the sum of £13,325, at twenty years' purchase . .	£266,500
Royalty of £350 yearly, at ten years' purchase . . .	3,500
Purchase-money	£270,000

The woods are included in the surface-rents of the ground, and estimated as shown before, and placed under the reduction that has been explained.

Land bears a low interest.

Land is computed to fetch the lowest interest of any stock in this country with relation to the purchase-money. The burdens, outlay, and trouble, anent the possession of it, are very considerable; and though the former may be ascertained with a very fair exactness, there are other expenses attending it which escape the common estimates of deduction. The nature and extent of the estate, its present and past condition, the state of the tenantry, the conditions of leases, and other circumstances, will exert an indirect influence, and not very small, on the eligibility of an investment in land. Annual holdings and short leases incur more expense than where long leases prevail: frequent changes produce wants and desires by reason of the objects being exposed to view. In addition to the regular expenditure which can be estimated, there is always a calculation of casual matters and unavoidable accidents, which fall upon landed property beyond any other kind of capital. It is very common to hear complaints of the great expenses of landed property, which are in many cases very true, and are much owing to the careless attention and system of neglect with which the possession is managed. The full value of landed property can only be derived by maintaining it in good order, and for this purpose the requisite expenditure must not be withheld, and the judicious and relative application of it is to be preserved with the most scrupulous attention. If a small revenue is derived from a well-ordered and replenished estate of land, much less will be obtained from a neglected property, which is daily sliding downwards, and will soon arrive at total worthlessness. An improvident management will soon destroy any property without a trace of the fortune that has been lost, while a foreseeing and ready outlay for all necessary objects will always secure a well-paid present income, and promote ultimate improvement of the estate. Incompetency is never more clearly shown than in the so-called economy of withholding the means to repair deficiencies and make them durable, when larger gaps will arise from the neglect, and in refusing an expenditure which would add some new sources, and also prevent the casualties of recurrence. In this way much of the expenses on land is heedlessly incurred.

Must be in good order.

Is easily destroyed.

Land much desired.

The inducements to acquire landed property ever remain to be very strong, notwithstanding the low interest that accrues, and the expenses that are attached. It possesses a more durable security than other kinds of capital; there is a fair expectation of a future increase of value, and there are many pleasing associations connected with the solid and enduring possession of a landed estate.

Is a firm security.

However much the thirst of gain may frequent the crowded ports of commerce, and haunt the walks of trade, no sooner has a large fortune been realized than it looks towards the land as the safest security. A rural retirement has ever formed a chief delight of the human race, and no wealth is able to find an equal, or to substitute the enjoyments. Superiority is ever pleasing to the mind, and there is more room in the vacant country than in the crowded town, where to show the exercise of power and the influence of wealth. The possession of land conveys with it very peculiar associations of inherited liking and pleasing recurrence, and there are attached to it many feelings of some little importance, which employ the fancy and divert the judgment. A proprietor of land is pleased to employ a happy labour, and to pay it; gratification associates with the learning of the clergy and teachers of the neighbourhood, and the justice and the magistrate are delighted to assist in dispensing rationality as law on disputed points, and to contribute in the advancement of morality. The residence becomes highly pleasing, and the employment most truly useful.

A gratifying employment.

CHAPTER XII.

LAND STEWARD AND FARM BAILIFF: QUALIFICATIONS AND DUTIES.

The land steward is a comparatively new official employment, having superseded the old manorial courts of audit, in which lawyers were necessarily employed. The post now requires a well educated and enlightened civilian, who is divested of the trammels and prejudices of a dogmatic craft, and whose mind has been very largely liberalized by a varied and comprehensive education. In the present days of enlightened and very rapidly progressive improvement of every kind, degree, and quality, it is most essentially necessary, that "the" person to whom the possessor of land has delegated the power of superintendence and direction over his property, be very intimately acquainted with the most approved modes of cultivating the possession, drawn from a systematic education and a regularly confirmed experience. For this purpose, the education must be commenced from boyhood; and especial care must be used, that the prejudices and trammels of the antiquated customs of a craft be not allowed to usurp the place of liberal ideas, and of reasonable and enlightened entertainments. In addition to the utmost extent of the usual education called "schooling," which is necessary to any profession, there is to be recommended for practical use and ornamental possession, a pretty extensive classical education, by which is meant a very considerable knowledge of, and ac-

Land steward

His education.

quaintance with, the ancient writers of Greece and Rome; from the perusal of which may be drawn the most liberal sentiments, and also the most elegant and ingenious, and which never fail to exert a most favourable influence on the professional transactions of any kind or degree with which they come into contact. They also tend very powerfully to create and promote that graceful affability of manner which is necessary for every person engaged in general business of a superior kind, where proper courtesy to inferiors, and the deferential respect that is due to superiors, are most imperatively required to constitute a negotiating "medium," for arranging and carrying on the business of the property. The use of a knowledge of these languages is undeniable in producing the aptitude of correct speaking and writing, than which there is not a more useful or ornamental part of a polite education. And no qualification more clearly shows the fitness of any person for a "business" occupation than the readiness with which ideas and conceptions are entertained, and the correctness with which they are quickly clothed with a becoming verdure of language, that is at once clear and intelligible, expressive and decorous, and which sends afloat in the commercial world as a current coin the very commonest transactions of business. Nothing more effectually contributes to the agreeable and faithful discharge of a mixed duty, than a graceful and pleasing affability of manner, and the prompt and correct use of the tongue and of the pen at all times, and on any occasions that may occur; and to produce these requisites, no branch of learning is more efficacious than an intimate acquaintance with the language and ideas of Greece and Rome, the two great theatres of human glory, from whom every succeeding enlightened nation has very unwillingly borrowed, and which many more have not yet equalled or approached. The common conversation of every person that is employed in the higher world of business, his intercourse with society, both vulgar and refined, his epistolary and business correspondence, and even his daily communications with servants and domestics, will be elevated and dignified, and even rendered more clear and intelligible, by being largely interspersed and ornately commingled with the "lactea ubertas" of Livy, and the "immortalis velocitas" of Sallust.

Classical.

Command of language.

Among the branches of education which are necessary to be cultivated by the person to perform the office of land steward, or the "curator and administrator" of landed property, an especial notice is due to chemistry, botany, geology, and natural history, as being all of them more or less intimately connected with the nature and organization of the particular species of property with which the management is charged. The studies and a fair knowledge of each branch are very often required to be exercised in the specific application where the use is attended with very beneficial effects. But if occasions never happen to call forth the use of them, the general knowledge that is created never fails to have a very beneficial effect on the other branches that are exercised. Such studies enlarge the circle of know-

Physical sciences

very valuable.

ledge, ennoble the sentiments, refine and exalt the ideas, and insensibly lead the mind to form elevated conceptions of every object and transaction that is presented to its comprehension and negotiation. The mind is whetted to vivacity of conception and action by the attrition of exciting causes; by the number and power of the mental stimulants that have been poured into the intellectual "sensorium," where by the action of fusion and amalgamation, a current of refined matter is produced and emitted, which improves every object that is touched, and burnishes with a brighter polish every transaction which is performed. It promotes every affair, and brightens every business.

Learning gives power.

A most powerful incentive to the acquisition of general learning is, that it gives to the possessor of it a commanding position in society; power is most gratifying to the mind of man, and the mental is so much more pleasurable than the material form of it, that it is exercised without the infliction of pain, and in its development it is innocuous, and meets with opportunities of conveying benefits to others, than which latter employment no exercise can be more agreeable to human benevolence. A corresponding station in society is essentially necessary for every person who is engaged in a respectable and useful employment; and it can neither be attained nor upheld without that enlargement and refinement of the mind which flows from a general education, and which alone can entitle any individual to the proud distinction. The position in society must be graced by the man, and not the man by the position. A general education points unerringly to the paths of eminence; it infuses virtue into every sentiment, and imparts a grace to every action.

Professional education;

The fundamental part of a professional education, must be that of the art or practice which is intended to form the occupation of the individual, and as the business of a land steward will be chiefly confined to the superintendence and direction of agricultural matters, it is most imperatively necessary that the person receives a practical education of the first order, and thus get acquainted with every detail and all the minutiæ of the art. This education must be the most improved, the most enlightened, and the most approved, which the age and country can afford; and care is necessary that this practice be not instilled at any age too young for the discrimination of ideas, and when the pliant ductility of the mind is too apt to receive and set down as the most incontrovertible truths the practices which only constitute the trammels and antiquated prejudices of the craft. The mind is thus stamped from without, instead of being moved from within, and becomes a passive recipient instead of an active exponent. Originality is wholly destroyed. To prevent this very common result of the general system of education, the study of practical agriculture is made to form the last part of a general education; and the branches formerly mentioned are previously acquired, in order that they may, by the power of their influence, liberalize the sentiments, and tend to neutralize the usual effects of an early infusion of prejudices and dogmas, which very often completely defy all future eradication, and produce very baneful results. On the other hand, equally as much care and caution must be used, that

liberal and enlightened:

the overheated fancies of scientific lore be not allowed to take the place of "rational" practice, and overturn the best laid schemes of prudence and discretion. The one part of learning must balance and improve the other; practice must show the results of every rational, and well conceived theory—and general learning will enlighten the conceptions, and by deduction show the feasibility of every scheme. Thus the two seemingly opposite elements of learning tend most materially to benefit each other; the meeting of the materials in the mind produce the the scintillations and coruscations that are so very necessary for the arrangement and transaction of affairs, and which illuminate every path and brighten every progress. If the mind be not stored to plenitude with valuable learning, it will quickly be occupied with lumber, trash, and trifles.

scientific & moderate;

A general education never can be mentioned, without a very "special" recommendation being always given to the study of mathematics properly so called. The word comprehends a wide range, and the branch must be extensively studied; for no education can be reckoned in any way complete without it; by it the mind is early accustomed to strict discipline: it learns to distinguish between causes and effects, to demand evidence for every fact, and a demonstration for every truth; and it dispels that very ignoble and infectious art of "believing" without evidence. Mathematics infuse a systematic order into every arrangement, and arrive by a strict method to every conclusion. No confusion is allowed; every thing is clearly placed, and produced from a regular concatenation. And so it must be in business, the arrangement must be methodical and clear, and the performance will be orderly, and the dispatch of it will be regular. A correct and wholesome discipline of the mind, is imparted by the studies of mathematics: it restrains the vagaries of fancy, and curbs the licentiousness of an unbridled impetuosity: at the same time, very pleasant truths are unfolded, and a trustworthy confidence derived in the ultimate results of any undertaking. These observations will apply to the practice of any liberal profession.

mathematic;

discipline of the mind.

Two stages of life will acquire the practical knowledge of agriculture; the first will be previous to the acquisition of the polite and liberal learning, and the other after that valuable acquisition has been made. Not less than two years should be allowed to each term of the apprenticeship. The first period will teach the mechanical drudgery of the business; and the second will look at agriculture with liberal views, and enlightened optics. Some years must then elapse in the acquisition of varied scientific knowledge, and in maturing and ruminating the practices that have been witnessed. No person must commence the office of land steward under the age of thirty years, or more; at which time the ideas will be matured, the experience extended, and the habits confirmed. An early age only employs a raw inexperience and an immaturity of intellect that can add dignity to no employment, and is productive of much mischief.

Age of business.

During the first term of the apprenticeship, the juvenile attention will be employed in the operations of daily farming, in the participation of the manual and bodily labours, of which an intimate knowledge is requisite. The second period of learning, will direct and superintend the employments, attend markets, fairs, and shows, at which much general knowledge may be acquired. A very material part consists in gathering a correct knowledge of the breeding and use of the improved animals of the farm, which now forms a very prominent part of the rural occupation. No branch of practical knowledge can be found more useful, or more conducive to the interest of landed property, and to the advancement of cultivation: no part of the employment is more rational or more truly delightful.

Tyroship of the juvenile course.

After the mind has been opened and liberalized by the study of the polite arts and of elegant literature, the attention must be most earnestly directed to the acquisition of the varied branches of knowledge, which will not only reflect a lustre on the profession, but will conduce most powerfully to the beneficial and satisfactory progress of the professional undertakings. The practical ideas must be concentrated and fixed; the habits of business must be chosen and formed; and the whole character must be graced with affability of manner and frankness of behaviour, which engage the attention of all who may approach, and always leave a very pleasing prepossession of remembrance. In the multiform varieties of a general business, no quality of the mind is attended with more beneficial impressions; it disarms hostility, and often wholly changes the frowns of opposition and the appearances of conflict. It is a quality of inestimable value; by it professional ignorance is often shrouded in a veil, and mistakes are slurred over, and pass unnoticed. When exerted along with other necessary acquisitions of office, it adds a brilliancy to every conception; and in business it gives a relish to every employment, and a passport to every intrusion. In promoting this very useful quality, a general education will be found to exert very powerful effects; and also in giving to the mind a stretch of liberality that is so necessary to every person who is engaged in the busy world, and whose attention is more particularly directed to the fruitful progress of a specific description of property. Early inculcated prejudices and rooted antipathies exert a most baneful influence on every human affair, and very often completely baffle all attempts of removal. For this purpose, a comprehensive and varied education should be very early introduced, which, by presenting to the mind the most varied assemblage of objects and opinions, will accustom it to the very useful task of analyzing and choosing, and will prevent the pernicious extremity of one idea or practice usurping the undisputed possession of the mind. Most men, or rather all men, have their crotchets, and the sooner and the more earnestly they set about the removal of them, the better. The mind is not sufficiently trained, nor the habits confirmed, for arranging and conducting an extensive and responsible business, till nearly the age of forty years, or considerably turned of thirty. Till that age, the constant

Varied learning.

Courtesy.

Crotchets must be avoided.

employment must be to gather information, and provide a stock of knowledge for future use, by acting in subordinate capacities. Age of forty years suitable.

A chief agent that has been thus qualified resides upon the estate of land, and not very distant from it; and in addition to the duties of the agency, may be charged with the direction of a practical farm, which the proprietor may or should carry forward, in order to show to the tenantry an example of the most enlightened practice. On this farm, all new theories, and rational experiments are proved on a suitable scale, as will not interfere with general results, and at the same time are sufficient to test the feasibility of the schemes that may be propounded. Such an establishment is very necessary in order to develope the resources of the property which is entrusted to the charge and possession of individual capacity. A farm necessary. The powerful spur of self-interest will also come into action; for wherever labour is judiciously employed, the recompense is certain from such quarters.

The duties of a chief agent on the days of audit in the receipt of rents, will be found in the last chapter of this work, along with the forms of notices, receipts, and cash books. The salary of such an agent is generally at £300 or £400 yearly, according to the extent of the charge. Salary fixed. A fixed sum is better than a per centage on the intromissions: it establishes a certainty which is useful in all cases. It also prevents any attempts on the part of the agent to increase unduly the amount of the rental, in order to raise his own emolument, than which insidious mode of managing any business, nothing can be more detrimental to the property, and disgraceful to the individual. All such temptations must be very carefully removed.

All monies are paid by the chief agent, and no arrangements are made, nor any undertaking carried forward without his privity and direction. The fixation and direction of all undertakings must be centered in one person, along with all subordinate departments; confusion will otherwise ensue, attended with clashings and collisions, and attempts at independence, which invariably produce damage to every concern that is interested. All accounts must be reduced into one collection, where the accounts are easily examined and viewed in connection. A properly adjusted establishment of a chief agent and his subordinates, resembles the staff of the general of an army, where the duties are most clearly chalked out for each department, and the means allowed for accomplishing the orders that are given. Regulations. In the conferences with subordinate officers, the agent must listen attentively to every suggestion that comes from the departments of office, and form an opinion from the statements that are given and joined with his own reflection on the separate points. He must always appear to be superior to the need of advice, and at the same time be open and willing to receive the hints and observations that may occur in the course of discussion. A friendly urbanity of disposition goes very far to promote that degree of willing cheerfulness, which so very powerfully advances the onward progress and fruitful termination of every un-

dertaking to which unity of purpose and cordiality of support are essentially requisite.

Visits frequent.

An agent must not be far distant from an estate of land, in order to enable a frequent and personal inspection of every proceeding, and of getting acquainted with the characters of individuals, and of directing every subordinate department. A constant and very minute surveillance must be exercised by him in every particular affair; and upon no account and in no affair must he rest satisfied with reports, nor allow the interested motives of those persons who approach him to influence his opinions or bias his judgment. To act upon hearsay, even on the most trivial occasion, shows a very great weakness in the powers of perception, and a disposition much too easy in the nature of compliances to enable the manly part to be called forth, than which no qualification is more required in the arduous situation of being placed between opposite and very often conflicting elements. A very vigorous enquiry must be made into the bearings of every affair, the truth must be discovered, and the decision and the future proceedings must be thereon made and directed. Nothing more effectually degrades a man placed in a responsible situation, than opinions crudely formed with hasty decisions, and actions imprudently executed, which are soon found to be wrong in temperament, and hurtful in the consequences. Perhaps in few or no offices of employment is there greater occasion for affability of manner, courtesy of bearing, calmness of judgment, and decisive energy of action when the resolution has been coolly formed. Hastiness and vacillation are equally the proofs of imbecility, that is most truly disqualifying for such an office.

Steadiness of purpose.

It must be laid down, and most tenaciously and inflexibly upheld as a fundamental maxim, that an estate agent must be an agriculturist of the most improved grade. Land-owners have committed most prodigious mistakes in employing lawyers, commercialists, or some similar persons, often of a nondescript character, whose sole object is ever to levy a sum of rental at any risk, and at the same time are utterly regardless of the source whence the profit is derived. Professional ignorance prevents any attention being paid to the furtherance of the art which supplies the revenue, and other engagements distract the necessary attention, even were it available and useful. The estate is seen only when the rents are due, and not again till that period returns: a manor bailiff is seldom kept, and no inspecting visitations are used. Under such treatment, all perishable articles fall into a state of ruin, as buildings, fences, roads, and the land itself; the rent is drawn so long as it can be got, and when the collection is no longer possible, a considerable sum of money is required to put the property into a vendible condition, which might have been wholly prevented by judicious regulations, and a timely interference, with a constant and vigilant surveillance. Very different must be the results to any landed property from the labours of a specially educated and duly constituted agent, whose time must be constantly occupied in the business of his remunerated employment, keeping accounts within doors,

Ignorance ruinous.

where also will be devised the schemes of improvement, and the means of accomplishing every undertaking. The personal inspection, very frequently repeated, will include the farms, plantations, and roads, and also the interior policies, except where the resident family take that department under a special direction. Faults and mistakes must be put right without delay, and the whole exercise is a most agreeable occupation for a rational being, and very necessary for upholding the value of the property. Even when a manor bailiff is kept, the visitations of the chief agent, are no less necessary; reports are apt to produce an improper bias, and misstatements are best removed by the evidence of the senses. In such inspections, a very patient and polite attention is required to all opinions and suggestions that may be given and stated, in *pro* and *con*; hints are got from such sources, and information needs every source of obtaining a proper knowledge. No person is degraded by listening to remarks from any quarter; something may be gained, and nothing is lost, and common civility is exercised.

Exercise pleasant.

The due authority of the chief agent controls the inferior departments on the estate, and there must be impressed the proper sense of that arrangement. Much confusion will ensue from this subordination not being properly understood and acted upon; co-operation will be disarranged, and malevolence and lurking hostility will be engendered. The chief agent must use his power "discreetly;" make his arrangements "judiciously and practicably;" give his orders "civilly," but "firmly and energetically;" convey the necessary censures "authoritatively, but blandly;" commend "freely, but duly restrictive;" and in every case. to judge coolly and dispassionately, and act decidedly and firmly. An ample supply of prudent discretion and a very great command of temper, are most essential requisites in such an employment, in order to meet the very frequent rebuffs and mortifications, arising from the perpetual collision of jarring interests, which naturally converge to the agent's position. This point very often forms the most arduous part of the official duty.

Authority.

In such situations, nothing is more necessary and becoming than the propriety of appearance and behaviour that belongs to the grade of society in which any individual may be placed. The land agent is exposed to the frequent contact of superiors and inferiors, and to both these grades, the proper deportment must be correctly exercised. To the former, a respect is due from the station in society, which expects opinions and proofs to be rendered with professional firmness, and suggestions offered with caution and prudence, as each special case may require. In such cases, an over-eagerness and heatedness are much to be avoided, which serve to produce irritation, and mar the face of proceedings. Towards inferiors, courtesy and affability are absolutely indispensable, in order to secure the goodwill and affection of the operatives in every undertaking, and who form the muscles and sinews of every active operation, Harshness must in all cases be avoided, even though the amount of provocation may apppear to justify the exercise: conciliation must form and cement the attachment; harshness will sever it.

Department.

The last, but not the least important, part of the duty of a land steward, is the correspondence, or communication with his employer, who is the owner of the property. The position in society often removes the land-owner wholly beyond any notice of the concern, and even his constant or temporary residence does not enable him to enter into any considerable knowledge of the business: the drudgery forbids it. The knowledge and judgment of the agent come into full play, as upon his opinions and course of proceedings, the prosperity of the property, and necessary welfare of the subordinate parts do in a great measure depend. The most enlightened professional knowledge must be joined with a cool and reflective judgment, and used with equal energy on trivial matters as on large undertakings. A varied education has been largely recommended in order to raise the ideas and elevate the conceptions above the mole-eyed plodding in the mud of vulgar practices and of obsolete prejudices, and of the clay-born sympathies that keep within the gin-horse track of daily routine. Judgment must systemize the conceptions, and steadiness must direct the attainment of every business and objects that may be contemplated.

Correspondence.

The owner of a landed property being necessitated to rely on the estimate and representations of the land-steward, and to give his sanction almost wholly to his calculations, there occurs the most pressing necessity that these estimates of opinion be composed on a very firm basis, and after a most mature reflection. Hasty decisions and crude calculations must be most carefully avoided, for the consequent miscarriages do much mischief, both directly and indirectly; they are exposed to contempt, and tend to prevent any future attempts of a similar nature; they also induce the proprietor to distrust the trustworthy confidence that ever should be reposed in an agent, and to think his own interference becomes the more necessary, and also to hear and consider other opinions on the subjects that come under consideration. The agent thus loses his proper "status" on account of these former misgivings, and also the confidence that is necessary to the undertaking and executing the beneficial improvements on the property. Envy and malevolence are ever ready to exert their evil offices whenever the least opening occurs. To prevent these gaps of offence, the most careful attention is required.

Correctness.

Trustworthiness.

The general and professional education of the agent must enable him to form ideas and concoct plans which will bear a severe investigation, and stand the test of the most rigid scrutiny. The language of conveyance must be clear, and easily understood, pithy and short: the answers will consequently be the quicker obtained and the easier followed. The agent's mind must be wholly occupied with his occupation, devising modes of necessary improvements, arranging the execution, and obtaining the consent and sanction of the proprietor, after there have been bestowed upon them the necessary explanations and elucidations. In this way, the universal benefit will be most usefully promoted.

The farm bailiff is a most useful person in the management and cultivation of landed property. It has been observed that there may be, or

should be, a farm conducted practically on most estates of land by the proprietor, and of which the charge will devolve on the agent. He delegates the resident power to a practical person for the purpose of executing the orders he may receive, and conducts every practical business from these orders, and his own special judgment. This person must have been bred from boyhood in the constant exercise of agricultural operations: at least to have acquired a most thorough knowledge of the nature and extent of each. It is most essentially necessary that he is a perfect master of every practical process in cultivation; for when a person is thus acquainted with any performance from personal experience, he is much better qualified to describe it, and to give directions on the subject, than if the recommendations were the mere results of observation, however acute and penetrating. In addition to these primary qualifications, the farm bailiff must possess as much education as enables him to keep a correct account of the daily labour on the farm, and of the corns in the granary as it is thrashed and sold. The form of the wages book is subjoined.

Farm bailiffs.

His qualifications.

WAGES BOOK.

An Account of the Names of Persons in the employment of , at , and of their Daily and Weekly Labour and Wages for Four Weeks, from the day of to the day of , 185 .

| Number. | Names of Persons. Employed. | Business. | Wages per Day. | Monday. | Tuesday. | Wednesday. | Thursday. | Friday. | Saturday. | Amount per Week. £ s. d. | Monday. | Tuesday. | Wednesday. | Thursday. | Friday. | Saturday. | Amount per Week. £ s. d. | Monday. | Tuesday. | Wednesday. | Thursday. | Friday. | Saturday. | Amount per Week. £ s. d. | Monday. | Tuesday. | Wednesday. | Thursday. | Friday. | Saturday. | Amount per Week. £ s. d. | Observations showing how each Person is Employed. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

The account is rendered monthly: the amount of the money is given to him, which he pays to the respective parties. The other accounts are given in as the transactions take place, and entered in the general farm account in which the weekly wages are entered in one sum, "as per bill" of wages.

Duties.

In order to ensure sobriety and steadiness as much as possible, it is better that a farm bailiff be a married person; for of all requisites in such an office, steadiness may be termed the very first, both in kind and degree; and in order to give encouragement to attention and activity, the wages given must be liberal, and constitute a sufficient reward for the tear and wear of the body and mind that are exerted in such an office. The dwelling house must be suitable, with a garden attached, and the keep of a cow is part of the salary, with a stye for pigs. The salary is usually £60 to £80 in money, the use of a saddle horse, and the usual appendages.

Labours.

The duty of the farm bailiff is to arrange and direct the whole processes of the farm, after consultation and concurrence of the chief agent who may have the chief direction. It is necessary that he is in the stables in the summer mornings soon after five o'clock, from 1st of March to 1st of October, when the harvest will be concluded. The necessary orders are given to the ploughmen, and the feed of oats is given to the horses from a locked chest, of which he keeps the key; and the same quantity is put into nose bags, and hung in the stables to be given to the horses during the interval of two hours for dinner. The bailiff sees all the teams of horses leave the stables at a quarter before six o'clock, which allows the work in the field to be commenced at six precisely. The time stops at eleven, begins again at one, p. m. stops at six, and so on; after that hour the bailiff is again in the stables, and feeds the horses with oats from the locked chest as in the morning. This finishes the necessary attention to the horses' labour.

Inspections.

After every order is given in the mornings and seen to be acted upon, the bailiff proceeds at seven o'clock to take the charge of the weeders of the crops, or hoers of turnips, in lads and women, and by a very constant attendance, he procures the duty of this branch of operators as firmly, as steadily, as conciliatory lenity will allow. From this employment, however, he must steal a march, once or twice in the day, to inspect the other works that may be proceeding, as ploughing, digging of ditches, road making, or any other business on the farm. His absence must be short, as "trifling" day-labourers require much care. A steady sense of duty will not allow any harshness beyond the proper obtaining of value for value. When due explanations are given, and no suitable return is made, the total separation is much better than the adoption of any coercion or vindictive proceedings. The bailiff sees the teams leave the stables at a quarter before one, p.m., when he takes his post with the daily labourers till the hour of six o'clock. In the evenings, after that hour, the bailiff may arrange with the servants the work of the morrow, always allowing the probable disarrangement by the weather, and other

accidents. On large farms, in order that the bailiff may have greater liberty of moving about, and inspecting the works of the farm, a steady labourer is selected to attend the gang of women and lads; and during winter, this person feeds the thrashing machine, and performs all the barn work. He leads the sowing of the grain crops, sows the turnips, and in harvest, he becomes the chief builder of the ricks of grain. This person is a most useful addition on farms of 300 acres, and upwards. He frees the chief bailiff of the most troublesome part of the farming drudgery, and usually gets one-fourth more wages than the ploughman.

An under bailiff.

The hay and corn harvests will require the constant attendance of the manager of every farm, and the turnip season is equally imperative in its demands for his presence. He must not be confined to any spot, or particular department of notice, but must move constantly about, and see that all operations are progressing, and are duly executed. During these times, all foreign business is laid aside, and the home matters are the sole concern,

A very chief care of the farm bailiff consists in his keeping every tool of the farm in the best acting order, the dead stock always in complete readiness, and the living implements in high spirits, and full of life and activity. The former is done by a vigilant attention, and the latter by kind treatment and conciliation. A harsh bailiff will lose his employer many acts of returning kindness: encouragement leads mankind; but harshness and brutality produce obduracy and retaliation.

Tools in order.

FARM ACCOUNT BOOK. 1852.

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	Horses	8

1852. Dr. *Rick Yard.* (1)

Date.	Folio.		Wheat.	Barley.	Oats.	Beans.	Peas.
			Ricks.	Ricks.	Ricks.	Ricks.	Ricks.
Nov.		To Crop, 1852 . .	7	10	16	4	3

This account shows the ricks that are thrashed,

1852. Dr. *Barn.* (2)

Date	Folio.		Wheat.	Barley.	Oats.	Beans.	Peas.
			Qrs. Bus.	Qrs. Bus.	Qrs. Bus.	Qrs. Bus.	Qrs. Bus.
Nov. 16	1	To Rick Yard . .	15 6				

This account shows the progress o

1852. Dr. *Granary.* (3)

Date.	Folio.		£ s d.	Wheat.	Barley.	Oats.	Beans.	Peas.
				Qrs. Bus.	Qrs. Bus.	Qrs. Bus.	Qrs. Bus.	Qrs. Bus.
Nov. 20	2	To Barn . .		15 6				

This account will, at any time, sho

1852. *Contra.* Cr. (1)

Date.	Folio.		Wheat.	Barley.	Oats.	Beans.	Peas.
			Ricks.	Ricks.	Ricks.	Ricks.	Ricks.
Nov. 16	2	By Barn	1				

and those that remain of each grain crop.

1852. *Contra.* Cr. (2)

Date.	Folio.		Wheat.	Barley.	Oats.	Beans.	Peas.
			Qrs. Bus.	Qrs. Bus.	Qrs. Bus.	Qrs. Bus.	Qrs. Bus.
Nov. 20	3	By Granary . . .	15 6				

thrashing and storing the crop of grain.

1852. *Contra.* Cr. (3)

Date.	Folio.		£ s. d.	Wheat.	Barley.	Oats.	Beans.	Peas.
				Qrs. Bus.	Qrs. Bus.	Qrs. Bus.	Qrs. Bus.	Qrs. Bus.
Nov. 30	4 & 14	By Sale . .	30 0 0	10 0				

the quantity of grain on hand.

1852. Dr. *Cash.* (4)

Date.	Folio.		£	s.	d.
Nov. 30	3 & 14	To Cash for 10 qrs. of Wheat, at 60s. . . .	30	0	0
,, ,,	8	To Cash for One Foal	15	0	0

The balance of this general cash account will

1852. Dr. *Expenses for Labour.* (5)

Date.	Folio.		£	s.	d.

This account shows the expenses of labour only, and saves

1852. Dr. *Petty Expenses.* (6)

Date.	Folio.		£	s.	d.

This account shows the smaller incidental expenses, and the amount

1852. *Contra.* Cr. (4)

Date.	Folio.		£	s.	d.
Dec. 1.	5	By Cash paid Monthly Wages Bill	23	14	3
„ „	8	By Cash paid for One Horse	25	0	0

show the final balance of all transactions.

1852. *Contra.* Cr. (5)

Date.	Folio.		£	s.	d.
Dec. 1.	4	By Monthly Bill of Labour	23	14	3

time in examining the general cash account for that purpose.

1852. *Contra.* Cr. (6)

Date.	Folio.		£	s.	d.
Dec. 8.	4	By Expenses at Market	0	7	6

is carried to the general cash account quarterly or half yearly.

1852. Dr. *Manure Account.* (7)

Date.	Folio.		£	s.	d.

This account shows the money

1852. Dr. *Horses.* (8)

Date.	Folio.		£	s.	d.	Horses.	Mares.	Foals.
...	...	To Stock on Farm	300	0	0	8	2	3
...	4	To Purchase . .	25	0	0	1	0	0

This account shows the dealings

1852. Dr. *Cattle.* (9)

Date.	Folio.		£	s.	d.	Bulls.	Cows.	Oxen.	Heifers.
...	...	To Stock on Farm	500	0	0	1	14	18	15
...	...	To Purchase . .	16	0	0	0	0	2	0

This account shows the numbers and value

1852. *Contra.* Cr. (7)

Date.	Folio.		£	s.	d.
Dec. 10.	...	By Cash for 10 loads of Dung, at 4s. . . .	2	0	0

spent for any manures.

1852. *Contra.* Cr. (8)

Date.	Folio.		£	s.	d.	Horses.	Mares.	Foals.
...	4	By Sale . . .	15	0	0	0	0	1
...	...	By Death . . .	20	0	0	1	0	0

among horses, the number and values.

1852. *Contra.* Cr. (6)

Date.	Folio.		£	s.	d.	Bulls.	Cows.	Oxen.	Heifers.
...	...	By Sale . . .	24	0	0	0	0	0	3
...	...	By Death . .	14	0	0	0	1	0	0

of the transactions among cattle.

1852. Dr. *Sheep.* (10)

Date.	Folio.		£	s.	d.	Rams.	Ewes.	1 year's	2 years'
...	...	To Stock on Farm	0	0	0	2	300	150	120
...	...	To Purchase . .	60	0	0	0	0	60	0

This account shows every

1852. Dr. *Swine.* (11)

Date.	Folio.		£	s.	d.	Boars.	Sows.	Pigs.	Hogs.
...	...	To Stock on Farm	60	0	0	1	3	16	10

1852. *General Loss on Stock.* (12)

Date.	Folio.		Horses.	Cattle.	Sheep.	Swine.	£	s.	d.
...	...	By Death . . .	1	1	1	2	38	0	0

This acccount collects all losses on dead and live stock, and shows the amount.

1852. (10) *Contra.* Cr.

Date.	Folio.		£	s.	d.	Rams.	Ewes.	1 year's.	2 years'.
...	...	By Sale . . .	60	0	0	0	0	0	40
...	...	By Death . .	1	10	0	0	1	0	0

lealing among sheep.

1852. *Contra.* Cr. (11)

Date.	Folio.		£	s.	d.	Boars.	Sows.	Pigs.	Hogs.
...	...	By Sale . . .	3	0	0	0	0	0	2
...	...	By Death . .	0	10	0	0	0	1	0

1852. *Goods from Farm as below.* (12)

Date.		House.													Stables.							Garden.			
	Folio.	Beef.	Mutton.	Pork.	Hams.	Cheese.	Poultry.	Eggs.	Milk.	Butter.	Price.	£	s.	d.	Oats.	Hay.	Straw.	Price.	£	s.	d.		£	s.	d.
		st.													qrs.	tns.									
...	...	40									4s.	8	0	0	10	0		20s.	10	0	0	Load			
																2		80s.	8	0	0	10 Dung	2	0	0

This account shows the goods sent from the farm for the use of a resident family.

1852. Dr. *A. B., Farm Servant.* (13)

Date.	Folio.		£	s.	d.	Wheat.		Barley.		Oats.	
						qrs.	bus.	qrs.	bus.	qrs.	bus.
...	...	To Payment . .	2	0	0	0	4	1	0	1	6

This account is fitted for payments in kind; when the wages

1852. Dr. *J. D., Corn Factor.* (14)

Date.	Folio.		£	s.	d.
Nov. 30	3	To 10 qrs. of Wheat at 60s.	30	0	0

This account shows all debts that may exist in business when no

This form of Farm Book-keeping may be enlarged or contracted to suit any circumstances of use, and columns may be added as required. Double entry is adopted, as it affords the most clear and effectual check

1852. *Account Current.* Cr. (13)

Date.	Folio.		£	s.	d.	Wheat.		Barley.		Oats.	
						qrs.	bus.	qrs.	bus.	qrs.	bus.
...	...	By 1 yr's conditions	10	0	0	0	34	4	0	10	6

are wholly in money, they appear in the monthly bill.

1852. *His Account Current.* (14)

Date.	Folio.		£	s.	d.
Nov. 30.	4	By Cash	30	0	0

credit is given for the goods sold. Each dealer requires a column.

and exposition of business. A simple entry merely states a bare fact; the double entry certifies the negociation, and vouches the transaction of the business.

CHAPTER XIII.

MANOR BAILIFF, WOODREEVE, GARDENER, AND GAME-KEEPER—THEIR POSITION AND DUTIES.

Where landed property is extensive, and lies in a wide circuit, the head agent of superintendence is removed beyond the drudgery of the inferior work, and retires to the higher duties. A constant residence is not made on the estate, but only the necessary visits, or an occasional abode for a period of the year. A subordinate authority and management is delegated to the manor bailiff, who lives in the centre of the estate, and performs all the lower duties, and attends the minor concerns. Such a person is essentially required wherever there is attempted to show a well-managed estate of land, as the detailed works of any undertaking constitute the perfection which is formed by the seeming trifles of attachment. All large establishments demand a staff of action that is efficiently constituted and systematically organized; and a methodical exactness must pervade every branch of the departments, even to the minutiæ that nearly escape observation. The profitable development of every large undertaking mainly depends on the constitution of the managing authority, and the mode and manner by which the action can be exerted, or is allowed to show an efficiency. The arrangement must be made with judgment, and directed with much care.

Manor bailiff.

The manor bailiff resides in some convenient central part of the estate, where a suitable house is provided, with the necessary attachments, and attended with a quantity of land sufficient to maintain a saddle horse and a couple of cows. The money salary is usually £80 yearly. He must be a steady trustworthy person, respectable, and well educated, thoroughly acquainted with the most enlightened agriculture in every branch and detailed appurtenance, and equal to any keeping of accounts. His time will be constantly occupied with the business of the estate, in arranging the performances with the chief agent, and superintending the execution. The wants of the farmers will first be made known to him, when he will hear the statements that are made, examine the grounds of validity, and judge the feasible sufficiency of being laid before the head agent for his approval or rejection. His own opinion must accompany every proposition; and it is most highly necessary that he is raised above partiality of representation, and the listening to reward. The vigilance of the chief agent must be ever awake on this point. An over-intimacy with any person or persons is to be discouraged, as it begets jealousy and destroys confidence. The preference is never to be shown to any individuals in priority of being served, except upon some

Residence.

Occupations.

very sufficient grounds, such as superior management, the greatest number of wants, or the want of repairs for the longest time. As all the buildings and repairs of houses will be entrusted to the manor bailiff, his knowledge must comprehend these performances, and be able to point imperfections, and check abuses. Measurement of works of all kinds must be familiar to him, and also of lands on the small scale of fields and pieces of land. If the farmers or workmen have complaints of wrong in the bailiff, the chief agent hears and decides the case; and if he prefers complaint against any person of the estate, the case is settled by the same arbitrament. The agent must exercise a keen enquiry and a sound discretion in deciding what may be purposely concealed from his knowledge.

Qualifications.

For the purpose of new buildings and repairs, the manor bailiff proposes plans and receives estimates from workmen, unless the estate be large enough to keep in employment the necessary operators of every department. These plans and estimates being sanctioned and signed by the chief agent, the works are commenced, carried on, and finished under the bailiff's superintendence, who draws money from the superior, with which to pay the subsisting money of the employed labour, and the balance that may be owing when the work is finished, measured, calculated, approved, and balanced with the money received. The value of the timber used is paid to the woodreeve on the estate, or bought from abroad, if none is grown that is suitable. The operations and items of detail will much employ the time of one person on an estate of land of the medium extent.

Proposals.

A very particular part of the employment of a manor bailiff consists in his visiting twice in the year every field of land on each single farm on the estate, and noting the management which is practised by the farmer. One visit is made in March or April, when the spring operations are being done, and the other in October, when the harvests are all finished, and the sowing of wheats is progressing. By riding round each field the condition of the gates and fences is observed, the neglects are noticed, and the improvements commended. An entry-book, carried in the pocket, contains these notices and memorandums, which require a convenient pen-case and ink-holder to be provided for the purpose, and to form a constant company. The rotations of cropping on each field of land must be very carefully noticed and entered in a book that is specially provided and adapted for the use of the bailiff: the size is a pocket folio of convenient bulk, containing on the left-hand leaf a plan of the farm on a reduced scale, with the fields numbered in a regular order and coloured, to distinguish grass from arable grounds, and woods from meadows. The right-hand leaf which is opposite the former, contains the number of years in single columns, which form the lease of the farm, in which is written the crop which the land bears in that year, as marked by the figure in the regulated order of seasons. This book is contrived and used for the express purpose of the chief agent and owner of the estate being able to know at any time the system of cropping, which is practised without the necessity of a personal inspection. A copy

Visits to farms.

Uses of a field-book.

of the book being sent the owner of the estate to any distance, the knowledge is transmitted of the arable management on which the prosperity of the estate is chiefly dependent. The use of the book is best made in the autumn visit of the manor bailiff, as at that time the land will most clearly show the effects of the system of cropping, if any injurious rotation has been followed and allowed, or a good one adopted and persevered. The introduction of any improper management is checked at once, and the manor bailiff must be able to judge of the admission or rejection of the proposed innovation, report to the chief agent, receive the matured opinion, and return the verdict to the farmer; not that the farmer is to be confined within the narrow limits that may be chalked out by any superintendents, or checked by their ideas, but there is a most imperative necessity that the intrinsic worth and quality of the property receive no damage, and that the policy be not retrogressive, if it is not advancing. This is the duty of all persons who are in charge of property, and land has the very peculiar attachment of being easily damaged, but not recovered without much time and expense. The manor bailiff comes into the room of the chief agent in observing and reporting the changes of use, and the benefits or damage of progress.

Twice-a-year

Correctly kept.

The visits of the manor bailiff will discover if the open drains, or large cuts for the conveyance of water, are duly opened to answer the purpose, and if the receiving outlets of frequent drained lands are in the proper discharge of the purpose. As was before observed in this chapter, the fences will form an object of interest, as ruined fences seldom admit being recovered, and new ones are long in being reared into use. In fact, every proceeding on the surface of the ground comes within the notice of the manor bailiff, who is a general inspector of every business, and performs a special part that is marked for his personal execution. Though the plantations are under the management of a special director, who is entrusted with that department, yet an observation must be taken of the condition of that branch of property, and of the mode in which it is managed and protected. The manor bailiff can observe and report of these and similar concerns, without exciting any malevolence or hostility, always observing a prudent discretion, and a courteous demeanour. As these departments are all under the jurisdiction of the chief agent, the delegation of the manor bailiff invests him with the surveillance of the whole parts of the landed concern.

Is a general inspector.

The few cases of putting under the management of the manor bailiff the making and repair of all the roads on the estate where he is located, have proved the beneficial effects of the arrangement in the improved condition of the roads, and the lessened charge of expenditure. The necessities of the paths of transit create a charge on the rent of the farmers, which is fixed on the pound of payment by the chief agent, who collects the money at the half-yearly audit, and places it in a fund to be used as the manor bailiff may require. He will appoint the number of workmen, as the work to be done will demand, and station them in dwellings upon or near to the localities on which the work is redone.

All roads under his charge.

And are well done.

quired. The digging of materials may constitute an extra item, and engage a contract agreement, or by special bargain; but the upholding of roads will employ a quantity of fixed labour throughout the year, which will mainly apportion the charge on the pound of rent to the farmer. The inspection of roads and farms is done at the same time, and becomes a business at once valuable and agreeable. This employment will form a distinct account in the hands of the manor bailiff, in which he will be debtor for all monies received, and creditor for all amounts paid. The making of new roads will be distinct from repairs, and must have a separate page, and a distinct consideration.

Gives notice of rent days,

The manor bailiff conveys to the farmers all notices of information that are necessary, and that by special delivery of hand. Even where fixed rent days prevail, the chief agent prepares and signs with his own hand a letter of notice to each farmer some two or three days previous, and sends the whole bundle to be singly delivered to each tenant by the manor bailiff. The form of these circulars will be given elsewhere. This delivery of notice is a part of the official routine of business, which is never to be neglected, even though the omission may seem to be harmless: it keeps attention alive, awakens interest, and by exhibiting care on one side of any concern, generally obtains a similar return from the opposite quarters. On the rent days, the manor bailiff sits closely by the chief agent, who receives the money, counts it after him, places the parcels in proper order, and keeps a separate account of the amount. If time allows, any observations on either side betwixt the agents and the farmer may be mentioned and settled, but affairs of any magnitude are best discussed at a meeting of special appointment. At all these occasions the manor bailiff is an essential presence, as he has seen the grounds of the request, and has heard all the urgencies and remonstrances that can be advanced.

and attends punctually.

The duties of the manor bailiff are separated from practical farming, yet the person must be capable of surveying that department; and if he does not intermeddle, his observations may still be useful. The roads and fences of any farm that is used by the landlord are equally under his care, as if let to a tenant, and he must exercise the same diligence to promote the advantage and sustain the utility. The young fences that are being reared on the estate till grown for the use of the farmer, are under the management of the manor bailiff, who has workmen located conveniently for the purpose, or the day-labourers on the roads may act in both capacities, and be separately accounted. Both purposes may be served by one arrangement, as one surveillance comprehends the objects to be done.

Fences and draining his charge.

When the draining of lands is being done on the estate, the whole charge of the execution may devolve on the manor bailiff, unless the extent of the property and the nature of it is able to afford, and requires a special appointment for the purpose. A gang of workmen may be kept for the separated purpose of draining, or the other workmen under the bailiff's jurisdiction may be used for draining when the performances can be so arranged so as not to get into contact and

create confusion. The bailiff must be competent on the subject of draining, and actively acquire and promote intelligence on that very important point of rural management. The leader of the workmen must be trustworthy in the absence of the bailiff; the course of the drains will be directed by their opinion, and the cavities filled as they direct. Where a manufactory of tiles is placed on the estate, the chief management may rest with the manor bailiff, with competent foremen to direct every separate branch of the business. These appointments will render the person a very responsible individual, and who has the power of very much promoting both practical utility and social contentment. These two objects constitute the chief aim of every human employment.

And tile making.

The office of manor bailiff now described, lodges on the properties of land that are extensive, to employ and maintain the highest orders of agency, and the value can afford the deduction of the cost. All estates should have a practical person constantly resident, and large extents possess that requisite in the manor bailiff, as the chief agent may be distant, and have similar employments, of which he incurs the responsibility without performing the drudgery. On smaller extents of landed property, the practical resident may perform every duty, assisted by a servant to carry messages and deliver written notices. The manor bailiff must be possessed with a sound judgment, enlightened views, and a conduct that rises above every symptom of partiality or under-cloak dealing. Every thing must be fairly and faithfully represented, and no reservation made of any points that require an open disclosure. He is better when free of any social connections with the population of the estate, and removed beyond mixing in any dealings with the farmers. An independent position must be maintained which can equal the appearance of superiors, and escape the unbecoming familiarity of inferior grades. Very much of the smooth and agreeable management of an estate of land will depend on the manor bailiff, who is placed on large extents for the express purpose of maintaining the connexion between the chief agent and the departments of operation. A very steady activity is required, which assigns each work the necessary portion of time, and upholds the performance of every duty in the proper period of appointment. Steadiness is almost the first of virtues in such employments, no display of uncommon energies on some particular occasions, and no momentary fits of unusual performances, though probably very valuable in themselves, can compensate for the derelictions of laxity and carelessness which succeed the periods of exertion. A vigilant observation and a steady execution constitute the foremost qualities of recommendation in any charge of operative performances.

Is the practical agent.

Must be independent.

Woodreeve is a person who acts as steward of any woodlands, and the defender and manager. The term is nearly obsolete, and comes from a word of the Saxon language, which conveys the above meaning. In former times, the woods were mostly planted by the seeds of nature, and the woodreeve merely ranged the grounds in order to debar any intrusion, and to preserve the wild beasts for the purposes of pleasure

Woodreeve.

and of the chace. Improvements were totally unheeded, and the reeve merely took the charge of protecting and defending the spontaneous productions of nature. A more settled order of society introduced other ideas of wooded property, and the system gained ground of making wholly new plantations of trees, and of much improving the old grounds that were occupied as forests. The reeve now became a regularly employed attachment of the landed property, and his duties were marked and defined as a subordinate in office to the chief agency. The feudal superiority was sunk into a useful appendage, and the haughty air of independence was lowered into the economical arrangement of a graduated subordination.

His office.

On large estates, and on those which do not employ a manor bailiff, the woodreeve is placed in charge of the whole plantations on the property and of the nurseries where such things exist. The dwelling must adjoin the largest portion of the woods, or be central as possible to the divisions of wooded lands, and have the accommodation of the grounds to keep a saddle horse and two cows, with the necessary small buildings. The money salary is £80 yearly. He will direct the felling and selling of timber in the proper seasons, receive all monies, and account for it to the chief agent. The planting of new grounds is a chief employment during the fresh months of winter; and the fencing of the grounds, and the protection of the young trees, constitute a part of professional duty that is not exceeded in value by any other department in the management of landed property. Whole growths of trees may be destroyed beyond recovery by the trespass of cattle during one single day, and no remedy can be found except by planting afresh the ground with trees in the quantity destroyed. The whole plantation fences over the estate belong to the province of the woodreeve; for, as observed in the article "Lease," the farmer has only to protect his fields, and the landlord who makes a plantation of young trees must protect the property he has enclosed for his own purposes. These fences require a most vigilant attention, and a constant outlook for the commencement of dilapidations, which may lead to gaps and entries of intrusion. A supply of ready materials in stakes and bars is a very necessary preparation, and so located as to be easily applied when needed for the neighbouring woods. The judgment of the woodreeve will be exercised in making these preparations, than which there can be no better fitness for office. The felling of oak trees and of peeling the bark will, on some estates, form a busy time with all woodmen, and is generally very profitably employed. The sale of these articles is managed by the woodreeve, and the receipts duly accounted. The winter sales of other timbers are similarly done, and rendered in the amount. The accounts kept by the woodreeve are only a debtor and creditor pages of receipts and payments, and rendered periodically to the chief agent, and placed by him in the proper department.

Position and duties.

In woods and fences.

It has been adopted to place under the charge of the woodreeve all the road-side fences on the estate, in order that they may add to the beauty of the scenery, from being better kept

Roadside fences his care;

than the cares of the farm might contemplate. The arrangement is good, only it will add some little item to the expense of the department of woods, but which will be inconsiderable in comparison with the improvements that may be effected. The gates of these roadside fences will be under the same care as the hedges, and both objects being kept in neat and efficient order will form an object of much pleasure and utility. It relieves the farmer of some part of the many burdens of his situation, and forms a step towards the suggestion in the article "Lease," that all the fences on an estate be managed by the care of the land-owner. The roadside fences have exhibited a very marked improvement from being under the charge of the woodreeve, in the few cases where the arrangement has been adopted,

and probably all other fences.

and it is reasonable to expect a similar condition of all other fences that are placed under the same authority. Whenever permanent objects are discussed, the land-owner's interest is ever foremost, and must take the brunt of the required expenditure in upholding the condition. A farmer patches a permanent article to make it serve his temporary purpose; the landlord erects and maintains the objects to serve the present time, and to extend the utility to future usages.

A nursery of some extent is very usefully kept on most estates of land that have a moderate extent, and though trees sufficient to supply extensive wants may not be raised, some number will be ready to meet moderate demands, and young thorns may be raised in any quantity to supply the wants of the estate. The nursery is the peculiar province of the woodreeve, and is best managed by labourers specially designed for the purpose.

The arrangements of the estate will allow the woodreeve a number of workmen which experience may find to be adequate to accomplish the quantity of work that has to be performed. The number will be altogether dependent on the extent and condition of the plantations; if the positions be distant and enclosures small, and need much planting, and if the timbers

His day workers,

be old, and much felling is to be done. In many cases, much work is done by contract, and the number of day labourers is reduced; but some operations do not admit being contracted, and are best done by daily oversight. The felling and topping of timber trees may be contracted, as the work is visible, and does not admit being imperfectly performed, and then concealed from view; and the raising of new fences may also be contracted, and let to the constantly employed labourers under the woodreeve, and these persons will be alternately paid by the day, or by the job, as the nature of the different works may require or allow. The gang of labourers must always be headed by a trustworthy individual, who receives the commands of the woodreeve, and who is mainly responsible for the proper execution of every job of performance, whether

and job men.

done by contract or day labour. Before contract work is extensively embraced, a confidence must be established between the parties, and a belief that neither one is overreaching the other, but that the establishment is made and carried on for mutual benefit. These understandings contribute very powerfully to the furtherance and prosperous result of any undertaking, and society is soldered and cemented by the

kind treatment and adequate remuneration which are practised by the employers to the employed, which has ever formed, and yet constitutes the heavy burden which remains to be discharged. The labourers must be all conveniently lodged in cottages over the estate, and not assembled in one place, but scattered singly, or in two dwellings together, and so placed as to exercise a surveillance over the woods, detect trespass, inspect the fences in the daily walks, and report promptly to the woodreeve, who will as readily issue the necessary directions to have the remedies supplied. The living of labourers in villages is very objectionable, idle congregations are encouraged, and gossiping assemblages spend time and divert the attention. The dwellings must be placed so as to communicate readily, and afford an inspection of some utility whenever the labourer leaves his home, whether he traverses a bye-way, or walks along the public road: the eye cannot be opened, without looking on some object of interest. A woodreeve with four or six men should manage the woods of a pretty extensive estate; but the number is wholly dependent on the quantity of wooded lands and the age of the timbers, and the extra work that may be attached to the department of the woodreeve. In the event of the land-owner assuming the management of the fences on the sides of the roads, as has been suggested, and probably of the whole fences of the estate, the charge of the woodreeve will be most prodigiously increased, and a delegation of authority will accrue to some trustworthy foremen, who will act under him, and undertake the charge and management of an assigned portion of work. The localities must be divided with judgment, and appointed with discretion. As before observed, all the dwellings must be planted with the view and for the express purpose of enabling a surveillance of some kind or degree being done by every operator in whatever capacity he may act, and under whatever charge his labour is exerted. Very much toil and trouble may be saved to the chief agents by arranging every subordinate as a part of the employment, and not as a driven slave, who toils for a grudged pittance, but as a willing actor, who is stimulated by motive, and impelled by gratitude. This is the only way of rendering human nature useful, and willing to apply its energies, by showing an interest in being employed, and a reward for exertion. Discontent should be wholly removed, and contentment is not at all beyond the reach of attainment.

Single cottages useful.

His foremen.

In the notice of woods as a part of landed property, it was observed that the expense of that department rested wholly with the nature of the estate, as it may be stocked with old timbers, or half-grown plantations, or is in an incipient condition, and require much original expenditure. In the two latter cases, no revenue will be derived from the wooded grounds, and the whole cost of the woodreeve's department will fall upon the estate as a primary outlay. A stock of full-grown timbers on any estate is an item of very considerable value, and enhances the price of the property more than the presence of it might suppose. Where a moderate quantity of timbers is ready for sale, such a portion should be yearly vended, as will cover the expense of the

Woods, young or old.

Sale of timber.

woodreeving, in the current-going item of outlay for repairs and necessary upholding; but the raising of new fences, and the making of new plantations, and all original work, must form a part of the general expenditure, unless a special fall of timber can be made to meet the outlay of money. If the yearly sale does not cover the whole cost of the woodmen, the greater part, or some portion being paid, will proportionally relieve the general burdens of the estate. Whenever a bare possibility exists, some relief must be given, but not to detract from future values by a premature use of the articles. This blunder may and has been done, and requires to be guarded against. Where no timbers are found for sale, the establishment of woodreeve will be reduced correspondingly, unless large doings are contemplated, and ample extraneous funds are at command.

Gardeners.

Gardener's office is wholly confined to the inside walled grounds, and the pleasure walks, roads, and shrubberies, that surround the gardens, and manorial residence. The department is most usually excluded from the inspection of the land agent, and wholly directed by the family of the estate. Nevertheless, a notice may be made of the arrangement which may seem just and equitable of that item in reference to a landed property. The expense of luxuries is seldom calculated and never regarded, consequently a much larger cost is attached to that department than appears in any part of the property. A garden of four acres is a provision for an estate of a very respectable extent, and allowing one man to an acre of ground, the head gardener will require four men em-

Duties and expense.

ployed within the walls; and if the outer appendages are large, as roads, walks, lawns, and shrubberies, two or three more hands will be required to keep all things in the state of trim neatness, which the practice of gardening understands. The average of six men with a head gardener, will require the sum of £300 yearly of maintenance only, exclusive of wants of seeds and flowers, which are uncertain and contingent. The employment of land in gardening, pays no rent in return for outlay, and is only to be placed to the account of unpaid luxury, that is both necessary and useful.

Gamekeeper.

Gamekeeper is an appendage of landed property, which is reckoned to be equally required with the other charges of protection. There is no doubt that the preservation of game animals, and a tolerably abundant supply of the different articles of that kind, forms, and even may constitute, a very great inducement to the possession of land, and were the arrangement not carried to a provoking extreme, no challenge would be given to the right of possession in the passing flights of rest on the grounds where the animals alight. Both pleasure and profit can easily be derived from that source of occupation, provided a relaxation and forbearance were extended to conciliate and not exasperate the feelings of a jealous inferiority. The department of gamekeeping is most generally managed by the landlord's own special arrangements, but like gardening, it may be noticed, and the relation stated with the other establishments on landed property.

One head gamekeeper will require about £100 a year, for his mainten-

ance, a pony, cow, house, and garden. Two assistants will be needed in £100 more, which will make £200 to be the yearly cost of maintaining the protection of game. The erection of extra establishments, and food for the animals that is given in the plantations, will form another calculation: the above is given as a medium thing, and to suit moderate views on that point. The estimate now given for that purpose, and likewise for the establishment of gardening, will no doubt fall very short of the general costs that are incurred on these points; but as they are matters of fancy rather than use, and promoted by whim rather than utility, a moderate approximation is stated, without regard of special arrangements.

Arrangement and expense.

The establishments of gardening and gamekeeping do not always, or rather very seldom, fall under the direction of the chief agent on an estate of landed property; but as the expenses are part of his disbursements, the notice is not to be omitted of the uses to which the money is applied. It may sometimes be his requested duty to give his opinion of the amount which should be incurred on each particular point of outlay, to make the arrangements, and to settle the establishments; and then his judgment will be called into action, in disposing the parts to suit the particular purposes, and in allotting the distribution of the general charge on the property as the different values may require. It is true that the two departments now mentioned, are almost a domestic concern, and need not the inclusion in the estate concern, but as the landed value supports every department, the very household arrangements must be made conformably and partake the same regulations with the other branches of the landed economy. The land and woods must have the first care, as they form the source of revenue which upholds all concerns: the other branches must be contented with such apportionments as the respective values and necessities may seem to require, and are able to justify. The chief agent must prepare an advice on all these points, which if used, may lead to pleasurable results; and if not adopted, it may not be less valuable, to be honored with a rejection.

Agent's judgment,

In making arrangements.

Whatever arrangements may be made in the case of the gardener and gamekeeper on any landed property, the chief agent must have the whole direction of the manor bailiff and woodreeve, as these offices do not form an independent separation, but are merely delegations of the business of the chief agent, and of which he retains the responsible execution. Hence a very regular subordination must be established and maintained by an understood dependence upon him, except in cases of last resort, when an appeal may be necessary to the owner of the property. These deputies are appointed by the approving knowledge by the landlord for their qualifications, and are moved by his convenience. No despotism must be exercised by the agent, but his authority must be supported in all reasonable jurisdictions, which are equitably dispensed.

His just authority.

CHAPTER XIV.

FIXED DAYS OF AUDIT—HALF-YEARLY PAYMENTS OF RENTS—FORM OF NOTICES, RECEIPTS, AND OF CASH BOOKS, GENERAL MAP OF ESTATES, AND OF EACH SEPARATE FARM—CONCLUDING OBSERVATIONS.

Fixed days of audit are best adapted to the systematic management of landed property, where nothing must be left to uncertainty that can be fixed, but all proceedings go on in the most undisturbed order. The times of receiving rents are of considerable import in the management of a landed estate, and the fixed periods are not less desirable. The days of audit are most generally arbitrary, and conveyed to the notice of the tenantry, in a precept from the receiving agent on the property. No doubt the known period of the year lets the farmer understand that the time of payment is approaching, and warns him to make a timeous preparation for the coming damage. Still he may trust to some little postponement of the day of audit, and neglect his diligence, and he may plead an excuse of not knowing the exact time for the neglect of readiness. Some other business of the agent may interfere, and induce the putting aside the rent-day for some time, and a vagueness is by this means introduced which is hurtfully extended into the other ramifications of business. Alterations of the day may follow, and lead into a month posterior to the customary time of clearing obligations. Such shufflings very much impair the efficiency of business, and totally disqualify any person from acting in the capacity of receiver of rents. Business hangs in suspense, uncertainty is prolonged, and accounts of every kind are kept behind, and fail to show the exact currency of affairs, in the purpose for which they are established. The closely kept state of accounts is the chief recommendation of any establishment, and no dilatoriness must be allowed in the very least tittle of amount. Activity is the soul of business, and punctuality with dispatch carry forward the whole machinery at the proper speed and rate of advancement.

Days of Audit

fixed and observed.

The best experience has established the payment of money rents half-yearly, or in equal halves, at the end of every six months, after the entry to the farm, and during the currency of the lease. No better mode of management has been devised, and it obtains the approbation of both parties in the giver and receiver. The best time of entry has been shown to be in May, in the middle of the month, or on the first day of the summer quarter of the year. The first half-year expires

Half-yearly payments.

in November, and in that month the first moiety of the rent is due. But to avoid the appearance of an anxious eagerness, and to indulge the confidence in the mutual transactions, that neither party expects any trickery or demur, a quietus of one month is given to the tenantry, and short as it may be, the utility, is not below an estimate. The middle of December, or the fifteenth day of the month, is fixed as the permanent day of audit, with the postponement till Monday, when the fifteenth day is a Sunday, and also if it falls upon a Saturday. Such assemblies give rise to hilarity which is sometimes extended to late hours, and all occasions should be avoided of unfitting the mind for the day of holy rest. The same day of the month of June, will be six months distant, and divides the year into equal portions.

December and June.

These times of the year, June and December, do not seem to be exceeded in fitness by any other periods, for the purpose of rendering the value that is derived from the use of the land. In June the farmer has received the sales of the grain crops, thrashed and vended during winter, and also the proceeds of the winter-fed beef, which will meet the half-yearly rent, and leave a surplus to aid the next payment. In December, the clip of wool, and the sales of all the summer-fed animals, will come into hand, and under particular circumstances, these receipts will exceed the values of the winter half-year. In grass-land districts, almost the whole proceeds of the season will be obtained at this time of the year, from cheese, wool, and grass-fed beef and mutton. And the period of the month of December, gives an ample time to the necessary transactions being done to meet the demand upon the farmer. No disadvantage is imposed upon him, of disposing any stock under value in order to meet the rent-day; and in June, he has had sufficient time to convert into money the grains of corn farms, and the winter values of beef and mutton, upon the lands that form the mixed cultivations of Britain. No faults have ever been urged against these periods of the year, where the times are duly observed, and regularly attended. Omissions and neglect may disturb, but not destroy the eligibility.

Best periods of the year.

Arrears.

The times of paying the rent of lands being fixed, and a month's quietus being given, it is very necessary that it be understood that no arrears are allowed, but that the full amount of the rent is expected on the day appointed, as all arrangements are made with that express view: nothing more contributes to embarrass any business than a number and a multiplicity of payments, which equally annoy and disturb both parties; the landlord never knows his income, and the farmer is perpetually bustling with payments. A mistaken lenity often leads to these confusions, and the demanding rents at improper seasons; the over-renting of farms, and an improper choice of tenants, tend to the embarrassments which involve much disagreeable communication, and create a very unprofitable state of affairs. To promote the non-existence of any back dues, an especial care must be used to place the tenant in a position to meet the exactness that is required, and to choose tenants who are capable and willing to use the necessary exertion under the circumstances that permit

the attainment. Arrears of rent are a certain index of bad management, probably on both sides of the business; but if other exactitudes are performed under the same circumstances, a suspicion may be inferred that the tenant is failing in duty, and requires to be observed: the land under his temporary use will be in arrear of management, and defalcations will spread into every branch of the undertaking. Nothing is more to be avoided in the management of any landed property; when the cash-book shows few or no arrears, the assurance is certain of the prosperous and thriving condition, that the landlord enjoys his income, and the tenants share the fruits of the arrangement. But when the contrary happens, when the column of arrears equals the receipts, and stands constantly filled with a full amount of figures, the suspicion is just, that the property is on the back ground, and the value and condition is diminishing. In a general view, arrears are most disgraceful to the superintendency of an estate, and many evils grow out of them. They encourage idleness and extravagance among indolent and thoughtless tenants, and are a disheartening burden to the industrious. To a receiver they are the cause of much trouble, and to a proprietor they are doubly embarrassing, as being the cause of intricate accounts, and of an uncertain income.

not to be allowed.

The remedy for arrears, as of every other malady, is to be suited to the cause. If it arises from over-renting, reduce the rent to an estimated fairness. If it be owing to over-indulgence, or to real misfortune, or to the known poverty of an ill-chosen tenant, and there is no prospect of the arrears ever being paid up—wipe it off. On the contrary, if the defaulter has substance, and there is a probability of his being able, one day or other, to clear the debt, lay it aside, and wait until a good year of fruits, or other favourable incident, occur for enforcing the payment. Standing arrears must be expunged, and current arrears prevented: the former by using means of due consideration, and the latter by establishing strict regulations to insure the punctuality of every payment. But when extraordinary circumstances do occur, judgment will be immediately called into action, and matured into an arrangement by the exact circumstances of the case. The occurrences of this nature require a just compensation, which no reasonable proprietorship ever can deny, or think of refusing. When the tenants are exact on the rent days, and pay the value of the farms readily and cheerfully, an equal willingness of promptitude must meet the occurring wants, and thus ensure the continuance of the strict and well-regulated system of deportment. Fire, tempests, loss of stock by accident, and other unavoidable calamities may befall the lower class of tenants, when it may be not only cruelty, but a very bad policy to demand the whole rent in the usual fulness of payment. Such cases are easily managed; a very bad crop of grains, or a large decline of prices, even though temporary, will, and must, induce a relaxation of the fixed rules, which are again observed, when the occasion of their being loosened, has passed away. Exceptions occur in every arrangement, and fixities are all liable to be shaken in their

Causes and remedy.

Prompt doings,

position. Arrears are a defilement to the rental of an estate, and constitute a stain both on the proprietorship and management of the possession. Every payment that is in arrear shows a want of arrangement in some quarter to meet the demand; it may be too large for the means, or the latter are not duly provided for the occasion; neglect is seen on both sides, too much is asked and cannot be found, and a fair value is not provided by reason of improvidence and an aversion to an honest exactness.

and no arrears.

A month before the day of audit, the chief agent will address to each individual farmer on the estate, a circular note signed by his own hand, reminding the tenant of the rent-day, and requesting his attendance. The bundle of letters goes to the manor bailiff, who delivers from his own hand, each letter to the special direction, which very much enforces the official notice contained in the circular. A trusty servant on small estates, acts for a manor bailiff, as such a person is occasionally employed in carrying orders and messages. The note runs thus:—

Written notice.

Fordhall House, 12*th May*, 1852.

Sir,

I beg to remind you that the day of audit for the receiving the rents of your landlord, Earl of ————, or ————, Esq., falls on the usual day of Tuesday, 16th of June, of this year, on which day the half-yearly rents due on 15th May, will be gathered in the King's Hotel, Wayford, at ten o'clock, A.M., when your punctual attendance is most respectfully requested, by, sir,

Your very obedient servant,

A B.,

Accredited agent and receiver.

To Mr. G. F————,

Tenant in Fordhouse.

This notice is delivered to every person on the estate, who pays a rent of any amount.

Precisely at the place and hour appointed, the chief agent arrives with his clerk, who has prepared the proper stamp receipts for each payment of money, and has had them signed by the receiver. The manor bailiff and woodreeve join the company in a suitable apartment, to which the farmers are introduced singly and in succession: a seat for a few minutes, gives the money rent to the receiver, who counts it, gives it to the manor bailiff, who also counts it, and if they both find the same amount, the clerk hands the stamped receipt to the farmer, who makes a suitable obeisance of mutual satisfaction, and retires. Another tenant is introduced, and is similarly treated, and so on till the number is exhausted. The clerk makes a scroll note of each receipt of money with the name of the payer; the money is put into parcels of twenty paper notes and of twenty gold sovereigns, which are all again counted by the agent and bailiff, after the business of receiving is over, and when the amount which they count agrees with the sum of the clerk's scroll account,

Day appointed for all parties.

the business is complete. When they disagree, a repetition is done, and the mistake discovered. It is very convenient when the banker of the proprietor lives in the town in which the rents are received, as he attends with his clerk, counts and receives the money, and gives the agent the note of transfer of the amount to the credit of his employer. When this arrangement cannot be done, the money remains with the agent till next day, when it is carried by him to the bank of the property in the special locality. The security of the money for one night rests with the agent, manor bailiff, and woodreeve, sleeping in adjoining rooms, the former being central, and having the cash in the apartment. The cases are most numerous where the latter way is adopted, as only large properties and contiguous market towns afford the convenience of a bank. But most landed estates of any considerable extent will employ this arrangement.

Proceedings.

Receipts. The receipts given in return for money rents, are worded thus:—

Wayford, 16*th June*, 1852.

Received on account of Earl of ————, or ————, Esq., the sum of eighty pounds sterling, from Mr. G. F., tenant in Fordhouse Farm, being the half-year's rent of that farm due on 15th May last, by the said Mr. G. F.

£80 Signed A. B.,
Accredited agent and receiver.

When partial payments are made and arrears do occur, a stamp is not required, and an acknowledgment is given on plain paper, stating the particulars, and writing on the left hand corner, the rent of the farm, the sum received, and the arrears due.

Thus:—

Rent	£180
Paid	100
Arrears	£80

This note will agree with the agent's book, and prevents the possibility of any mistakes.

The receiving agent fills up the general cash-book of the estate from the scroll pages of the day of audit, placing every receipt of money in the proper assignment, and any disbursements to the proper account of use. These are the employments of his home retirement, where with his clerk he adjusts the items, and schemes the regulated expenditures. Where it is not convenient for the proprietor to see the general books of the estate, a copy sheet of each year's proceedings is regularly sent him.

Cash-book and copy sheet.

It is not unfrequent that the landlord treats the tenants with a dinner at least once a year; and it may happen in June or December, as may

be arranged. In that case, when the farmer is bowing retirement from the audit-room with the receipt for the rent in his hand, the agent will be glad to see him again at four, five, or six o'clock, as the hour may be fixed for dinner. At the other half-yearly audit when a dinner is not given, a glass of wine is handed to the tenant in the audit-room, when the money has been paid, and the receipt delivered; and this acknowledgment ends the intercourse for that day. It is best arranged that little or no public business is done by the agent on the days of audit; the money matters will very sufficiently occupy the attention, and the memory must not be crowded with a multitude of proposals, which may be too hastily considered, and improperly regarded. On such occasions, advantage may be taken of a hurried employment to convert into promises the probably unguarded words of passing observation, and which require a much more grave consideration than can be bestowed upon any subject in these hurried moments of occupation. But on the last-mentioned day of audit a leisure may be got for the hearing and answering the appeals and proposals of the tenantry; and in long cases, the answer can be afterwards returned through the manor bailiff. Separate days, or one in every half-year, may be appointed for the purpose of hearing proposals, and meeting demands, which may be fixed as are the audit-days, and have the same consideration given to their importance. In some instances, the days of audit are held at the mansion of the proprietor, when the same forms of business are observed as at the public resorts.

Dinner.

No business on the audit-day.

The subjoined form of a cash-book for an estate of land, may be altered in any way to suit the circumstances of attachment, and may afford the grounds of adoption in most cases.

Books.

Crop 1852.]

Dr. *Estate Cash Book.*

Names of Farms.	Possessors' Names.	Rent.	£	s.	d.	Date.	Cash Received.	£	s.	d.	£	s.	d.	Arrears.	£	s.	d.
Newstead	A. B.	Money Burdens, if any	280	0	0	15th June	Half Year's Rent ...	140	0	0							
						15th Dec.	Ditto...	140	0	0							
			280	0	0			280	0	0							
Grange	E. F.	Money Burdens, if any	600	0	0	15th June	Half Year's Rent ...	300	0	0							
						15th Dec.	Cash ...	240	0	0							
			600	0	0			540	0	0				By E. F.	60	0	0

This Book shows the rents received, the arrears, the expenses on each farm, and the whole charge of upholding the estate. It may be continued to any extent, and have attached to it the general receipts of money from

Crop 1852.]

Contra. Cr.

Date.	Expenses.	£	s.	d.	£	s.	d.	£	s.	d.
18th July	By Cash paid the Carpenter's Bill for Repairs, as by Account rendered.....	55	17	0	55	17	0			
16th Sept.	By Cash paid the Mason's Bill for Repairs by account.....	15	6	6						
	By Cash paid the Carpenter's Account	10	8	0						
					25	14	6			
					Total			81	11	6

other quarters, and also the general expenses. Abstracts of each department being joined together will show the result of the whole proceedings.

Brevity and simplicity of arrangement constitute the essence of the art of keeping accounts, which are to be so designed as to afford at any time from a slight inspection, a clear and satisfactory view of the existing state of affairs. There must be no dilatoriness of entry of the very minutest trifle; every transaction must be recorded within twenty-four hours after being done, and show the negotiation in the place of proper exhibition. Nothing is left till to-morrow which can be done to-day, and each night must show the business of every kind arranged as it has been done, and duly noted. No other way is able to direct the current of affairs in the proper channel, or control the tendency to go awry.

Short and clear.

The following very concise and simple form of a book of receipts and payments, may be found useful in certain places of an extent not very large, and where the proceedings require to be closely shown, and narrowly guarded. Its chief use consists in giving a view of gross receipts and disbursements, and showing the balance of money that remains in hand. It is a concise abstract of general proceedings, and has been found very useful under circumstances which require an understanding of that nature.

Account in respect of Receipts and Payments at for one month, or from weeks ending 1852.

Dr. *Cr.*

Receipts.			Dates.		Particulars of sums paid and received.	Payments.		
£	*s.*	*d.*				£	*s.*	*d.*

Bailiff's office.

It is conveniently and very beneficially arranged that there be attached to the residence of the manor bailiff, an office-room of public resort, at which the bailiff is found on most days of the week and settles the business of the estate that requires the transaction of being put into the form of writing. This office of two apartments in the outer and inner rooms, may be joined with, or placed at a small distance from, the dwelling-house of the bailiff, and to it the chief agent may be appointed to come on the fourth Wednesday of every month, or any other day or week as may be eligible. The farmers and all the subordinate agents know this appointment, and attend it, when reports are made and suggestions heard and settled. The manor bailiff and woodreeve

refer all matters to be settled at this meeting, and the tenants look to it as the termination of all cogitations and proposals. In this office are kept all the books of general reference, and the maps, which require very often to be consulted. On estates of the smaller extent, the agent will be of the minor grade, and perform the whole business of agency and of the bailiff; the office will be attached to his own dwelling, and answer the purpose above described. When he resides at a distance, an occasional residence may be found on the estate, when the monthly attendance at the bailiff's office will be more convenient, and more easily attended.

Where to meet and consult,

In some cases of landed property on which the idea of hospitality is not entertained or largely distributed, the office at the residence of the manor bailiff or inferior agent, may serve as the place of audit, and the rents can be received in the two rooms of office. This arrangement does not abandon the monthly day of meeting at the office, as it is exclusively devoted to the receipt of money, and the other time to the transaction of contingent business. The residence of the proprietor may have an office attached, where every agency is done: on largely extended estates, the offices of business may be two or three in number, in order to suit the distances of detachments. At each place the agency must occasionally attend in order to inspect the demands that are made, and to diffuse a spirit of good order and emulation. In these offices, there must be lodged the necessary provisions for the transaction of business, as maps, rentals, books of accounts, registers, and receptacles of business that has been transacted. No person must carry away on any occasion, or for any purpose, a paper of any kind from the office, without leaving in its place, a memorandum, stating by whom it was taken, and for what purpose, and when it will be returned, in order that it may be traced in case it should not be brought back. This regulation should be written in large letters, and suspended in the most conspicuous place of the office. Such an injunction requires a positive enforcement.

may be the place of audit.

A rent-roll is required on every estate of land, or a statement of the gross value of the property, ranged in the order of the farms, and other sources of revenue, as woods, mines, rights, and fines. This general view of increase is best arranged in columns, as being most perspicuous; and for a schedule of farms the following are proper:—

Rent-roll.

1. The mark of the farm in the general map.
2. The names of the farms.
3. The contents, or admeasurements of each.
4. The names of the present tenants of each.
5. The amounts of the existing rents.
6. The outgoings, if any, by the proprietor.
7. The expiration of the lease.

The farms are best arranged geographically, in the natural order in which they lie on the estate, and thus appear on the rent-roll. The general roll-map of the estate, the book of maps, the large rotation book of maps, and the pocket-book of maps, must all agree in having the farms similarly

marked, and arranged in the same order, and also in the receiver's general cash-book, and in fact, on every occasion of the farms being placed in order of any kind, a systematic mode of proceeding must be adopted, practised, and enforced; and when neglected or infringed, it has to be immediately restored.

Maps of estate.

Estates of land must be mapped in the whole extent by a competent surveyor, or of the districts, or officiaries into which a large extent may be divided. These provisions will be lodged on rollers, and unfolded on the floor of the office when a general consultation is required. On a reduced scale from this map, there is constructed a book of maps, in which each separate farm is contained on a leaf which extends over the whole book when opened, and the middle of it bends into the centre of the book when it is folded. This volume forms a ready reference to each single farm, and can be carried to any place to be examined on the spot for the purpose of certification. In the reduced scale of one-half of these maps of estates, the general book of rotations is made, having on the right-hand side the plan of the farm, and on the left the rotations of cropping during the currency of the lease, as has been shown in the duties of the manor bailiff. And on all suitably reduced scales from these plans, the pocket-book of maps and rotations is constructed, so as to be convenient, and easily portable. All these plans being fitly done in one copy by a professed surveyor, can be copied into any useful number by an official who has received an education that enables the performance. At every office on an estate of land, there must be lodged within its walls, the book of maps, and the rotation books of the districts which lie within the circuit of the officiary; reference will be constantly necessary, and the provisions must be had. The original copies of professional skill will remain at the chief office, the others are copied as substitutes.

Books and single

The plantations are separately mapped, and shown in the office or offices to which the position of the woods appertains. And when a new planting of trees has been done, a plan is made of the plantation ground, in order to answer the special purpose of necessary references. The woods are ranged in the numerical order, and a book with columns contains the extent of each plantation, the age of the timbers, the time of last cuttings, and the money got from sales, with the respective dates attached. The quantity of hedge-row trees on each farm may be entered in a similar book, and accounted as they may be cut down and disposed for use, or sold. The manor bailiff and the woodreeve prepare and keep these books, and the chief agent examines and approves. On the inferior agencies, these performances fall upon the steward himself. These cases often join the duties of bailiff and woodreeve in one person, who will assist in upholding the provisions that have been mentioned.

maps of plantations.

Accounts.

On every estate of land there must be established laws and usages, to which both parties are liable, though no written contract subsist on the subject. Though these laws may be imperfect, they ought to be strictly observed, until better regulations are found: moral justice demands the

performance of these duties, and the example must be set of integrity and good faith to the tenants. The proprietor and agent must show the model; for if these persons break customs and covenants, what can be said to a farmer who follows the example? It is no more than common prudence to fulfil with scrupulous exactness every covenant and agreement, and every promise that has been made, even to the meanest cottager or labourer on the property, in order to inspire the same principle into the conduct of every person that is concerned. Not only good faith must be preserved, but good offices; and frequent acts of kindness must liberalize the minds of the tenants, and not with any loss, but with a positive advantage to the estate. Spirited improvers must be denied no reasonable request, and should have favors voluntarily conferred upon them. Estates, like men, acquire good or bad characters, and not from the quality of the soil, but from the conduct that is observed in the arrangement and treatment of the negotiations. A skilful farmer of capital will rarely fix his abode on an estate of bad repute; while on the contrary, a contest will happen to obtain a footing on a property of established character. Nothing can well add more to the permanent respectability of a family of rank and fortune than having the estates occupied by a wealthy and respectable tenantry.

A scrupulous exactness.

Character established.

The good management of a landed estate requires the assistance of a law officer, as solicitor, or attorney. This person is employed as an assistant when required, as is medical aid when specially necessary. Judicious regulations and timely advice without interference will almost prevent any serious divisions on the estate; yet cases will occur from the frailties of human nature, and in a state of civilized society, and of established property. The lawyer is best engaged on large properties to manage all legal affairs for a yearly stipend, which may be sometimes exceeded, but oftener below the mark. The land surveyor is employed when the professional service is required, and is often a useful person as an arbitrator or referee.

In every business between man and man, the affairs must be made pleasurable, and transacted cheerfully, as the matters occur, and never delayed, till by accumulation the performance is difficult and irksome. Dispatch is essential before misunderstandings; idle tales, and groundless surmises have time to intervene, sour the mind, and produce a distant coolness. Barriers are thus raised, which nothing but the mystic law may remove. No tricks or artifice to take advantage like gamblers round a table, but an honest desire to find the point of equity and right, must be the chief motive; and when honest men, who have character to lose, meet to settle any business, the difficulty very quickly vanishes. An umpire may be necessary at times, but the occasions will be few.

No arrear of business.

On the part of persons in power, a conduct of a somewhat peculiar mark has to be observed, in order to give no offence to superiors, to please the equals, and to conciliate inferiors. A demeanour at once respectful and firm must be exhibited by agents, in order to procure respect and observance of regulations. No arrogant

Conduct of persons in power.

haughtiness nor austerity of manner must debar the approach of solicitation, nor must an improper familiarity allow the intrusion of every petty squabble or request that may suppose itself worthy to be heard. The former line of conduct prevents the necessary access of presence, and the latter crowds every avenue with trifling advances. No quality is more hurtful in an agent of any kind than the want of a firm decision; the resolves must be decided and adhered to with pertinacity. Inferiors must be taught into a respectful submission, but no slavish cringing, which wholly destroys the independence of mind which must ever accompany the use of any rational faculty. A courteous affability must be very largely entertained with every person, of whatever rank or station, that requires to use the agency of the estate in any way; no cold repulsion is to be used, nor a feeling of disdain be manifested, unless on the proper occasions, which must be well settled and authenticated. A demeaning familiarity must be very carefully avoided, as it tends most powerfully to lose esteem, to sink respect, and never fails to beget contempt for the object of its exercise. There is a happy medium of conduct which pleases superiors and conciliates the lower stations of life; it is a most valuable acquisition, as it procures confidence from the former and attaches the latter, who form the supporting groundwork of society. In the days of audit, or at any other times, the agent of extensive business must not trust to promises in a crowded memory, but reduce every business into writing, when it is of the possible import. An occupation being arranged in this way, and the habits of transaction being adapted to the circumstances of the position, and a systematic organization being on every point established, there is only wanting the polite affability and courteous demeanour which gilds every object and burnishes every business, gives oil to the wheels of affairs, and lubricates every transaction.

Firm decision essential,

and a clear memory.

Such an important subject as the charge of landed property cannot be dismissed without a parting admonition to the holders of these offices. In many cases the total absence, only a temporary residence, and the occupation of the land-owner in legislature, leaves to the agent the almost uncontrolled direction of the estate; while in almost every instance of an agency of repute, the advice of the professional adviser is as it ought to be—decisive of the system that is adopted. The agent will see that he is entrusted with the physical and moral condition of a portion of his fellow-creatures, who have a claim or vested right to be employed, maintained, and educated by the property of which he has the administration. His employer has bought a certain part of the developement of its resources, and this being the acting portion, must have its every direction made to tend to the chief points of attachment. This employment becomes a very serious concern to a rational being, who must assume a corresponding lofty standard of morality in every sense and meaning of the word. The agent has to hold in constant perspective the employment of the people, and a competency of support; the education, moral and religious, accompanied with such a remuneration to his employer

Moral responsibility of an agent;

as will justify the progress of the undertakings. These purposes form a most important charge to be invested in any one person, and require a thoughtfulness the most serious, and a calculation the most profound. It is no every-day affair, or passing concern, but a matter the most valuable of all the varieties of occupation. Those persons who write about man, and the different states and stages of his existence—moral, social, and political—would do well to remember two things: the cultivation of the earth, and the supply of the necessaries of life; for they uphold or overturn all their ideal fabrics.

and most important charge.

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ERRATA.

Page 224 line 24, *for* I K 66 *read* I K 6.

Page 467 line 9, *for* A A, fig. 194 *read* A A, fig. 187.

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8 Parliamentary Plan of a proposed Railway.

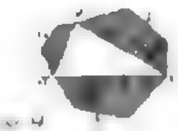
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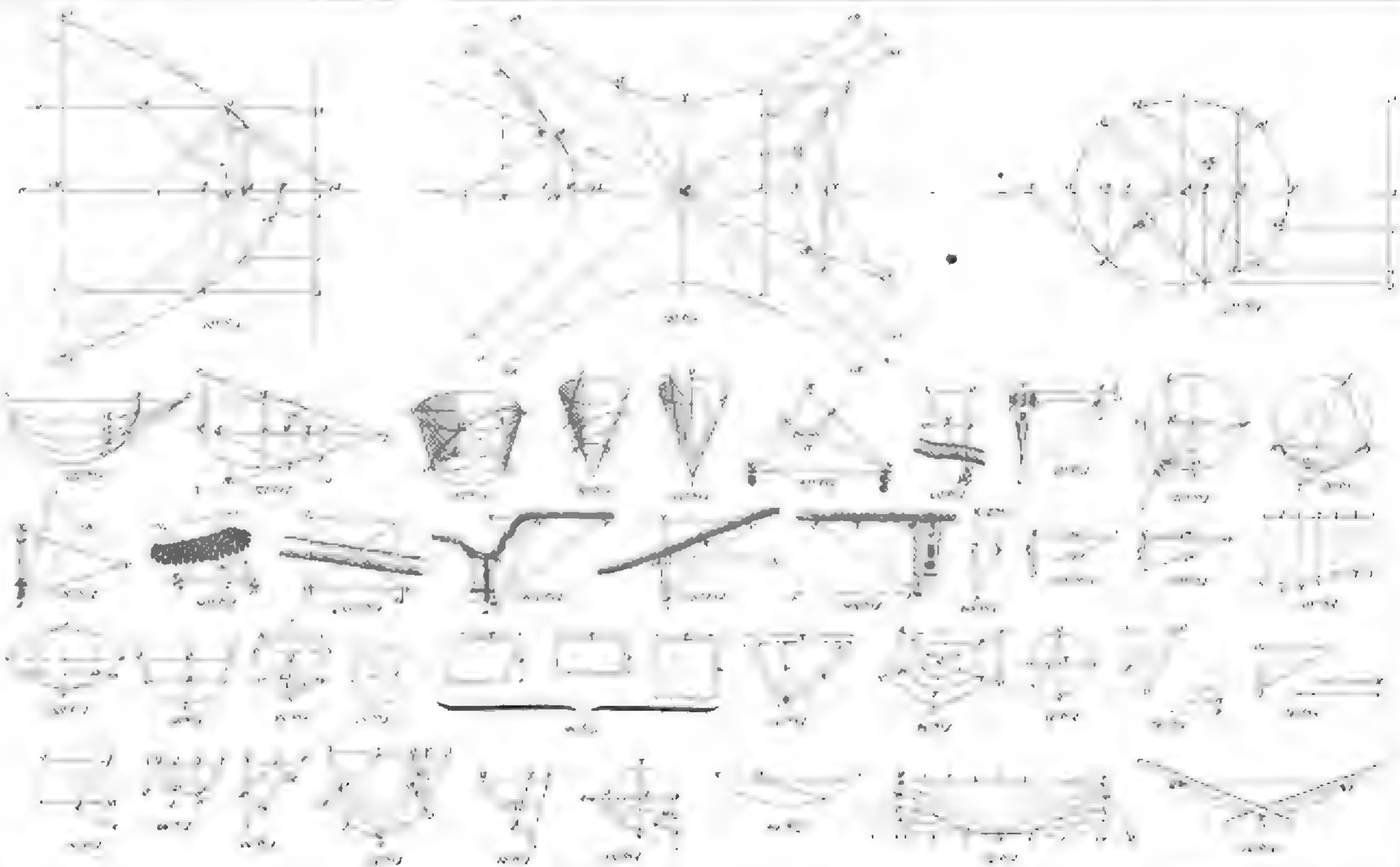
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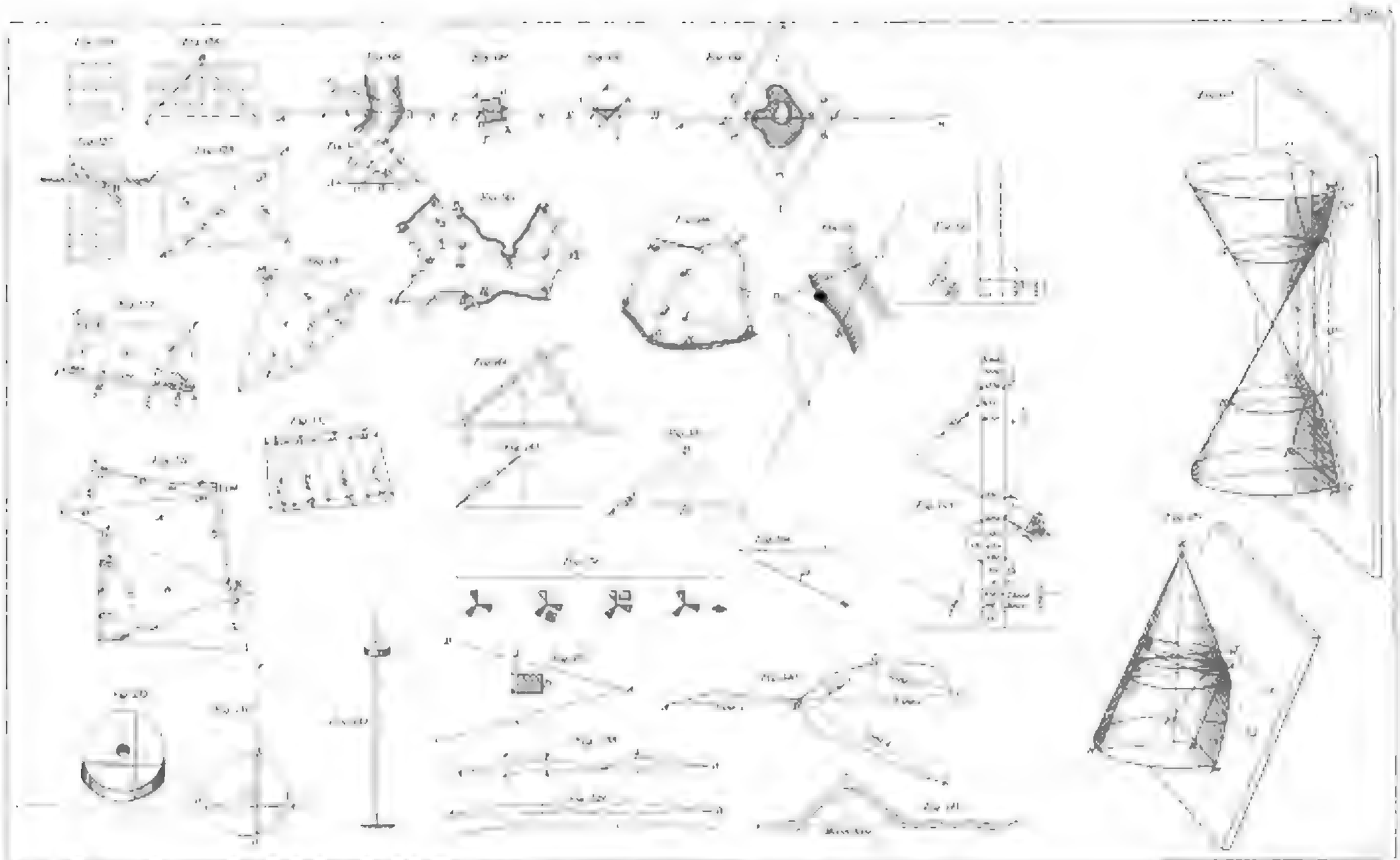
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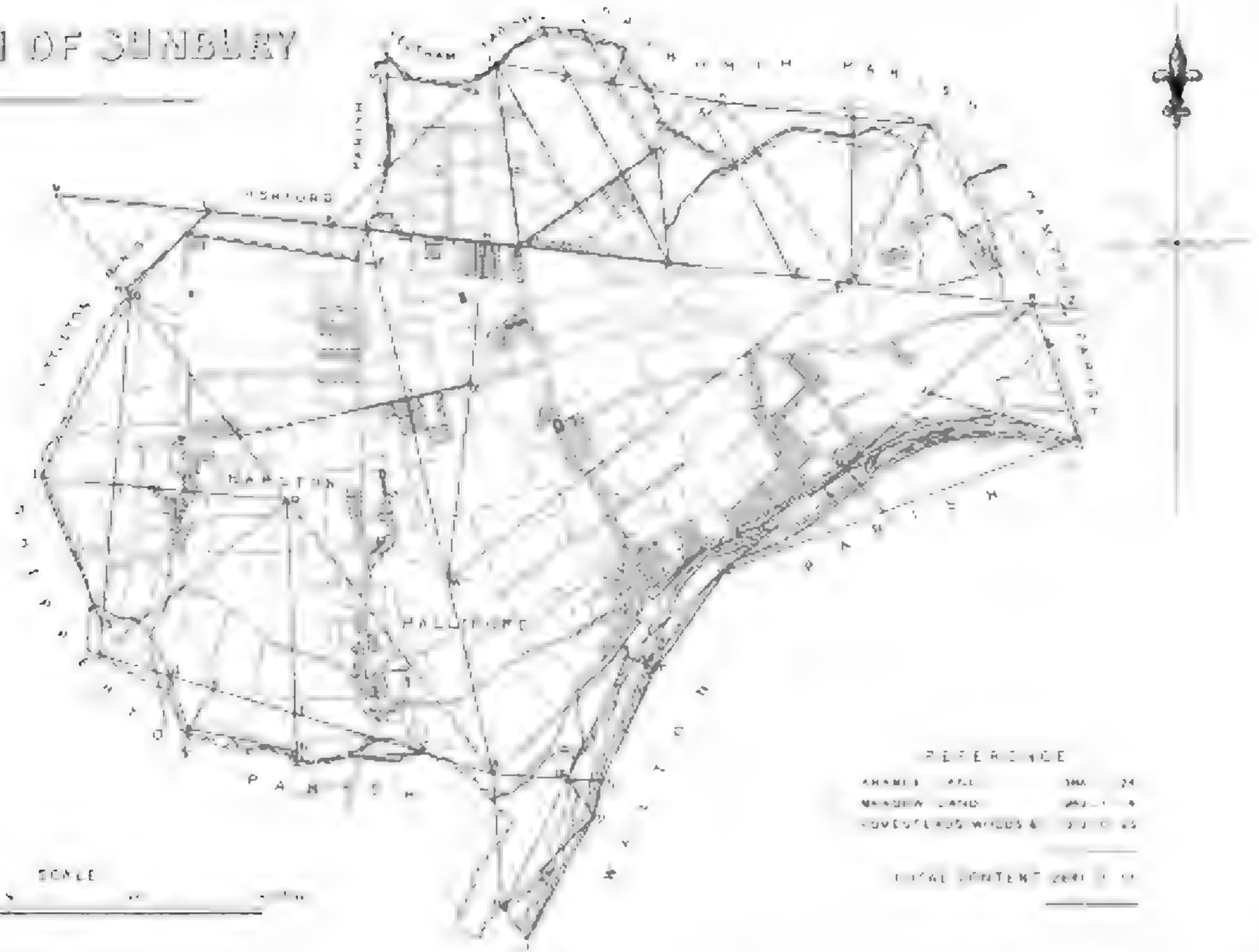
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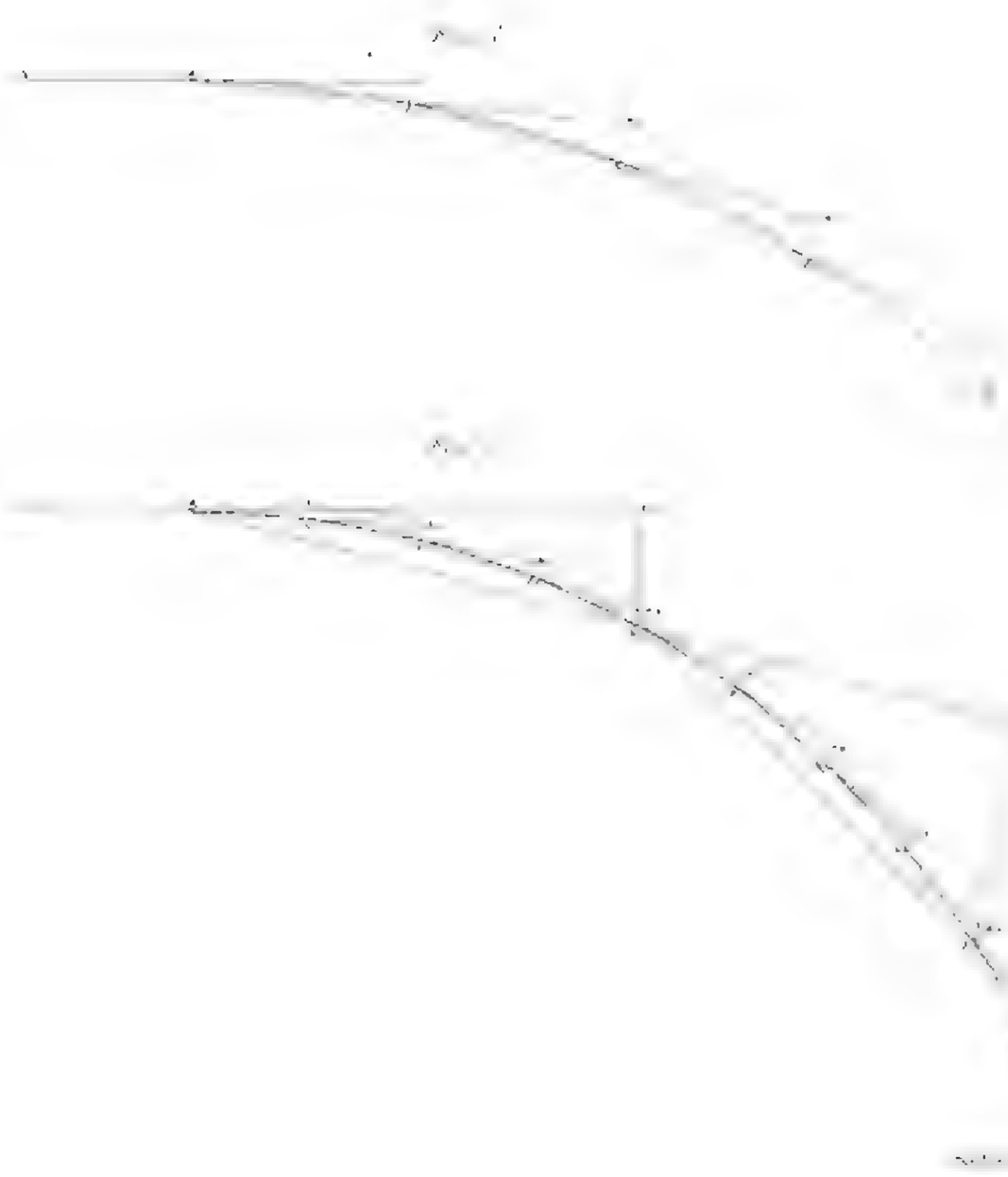


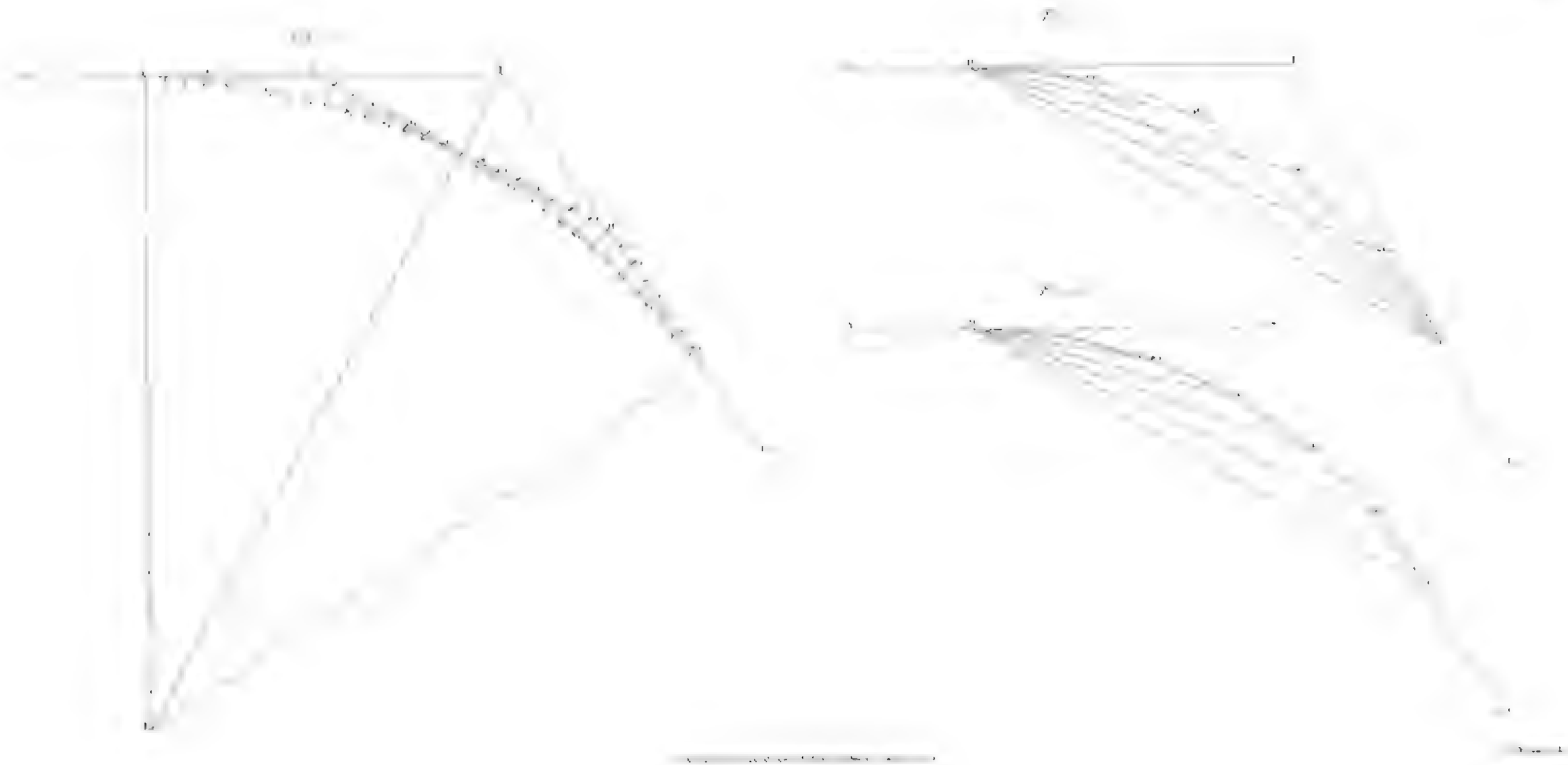




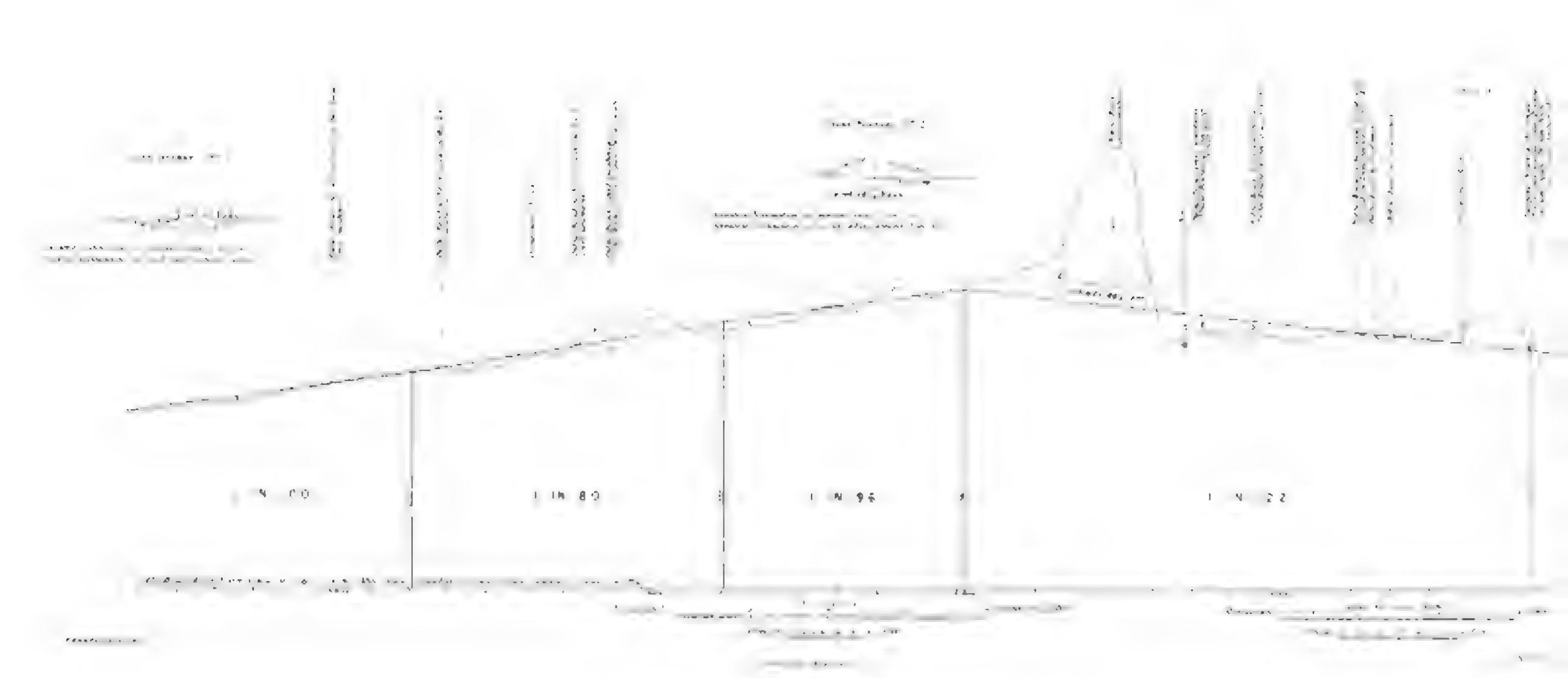
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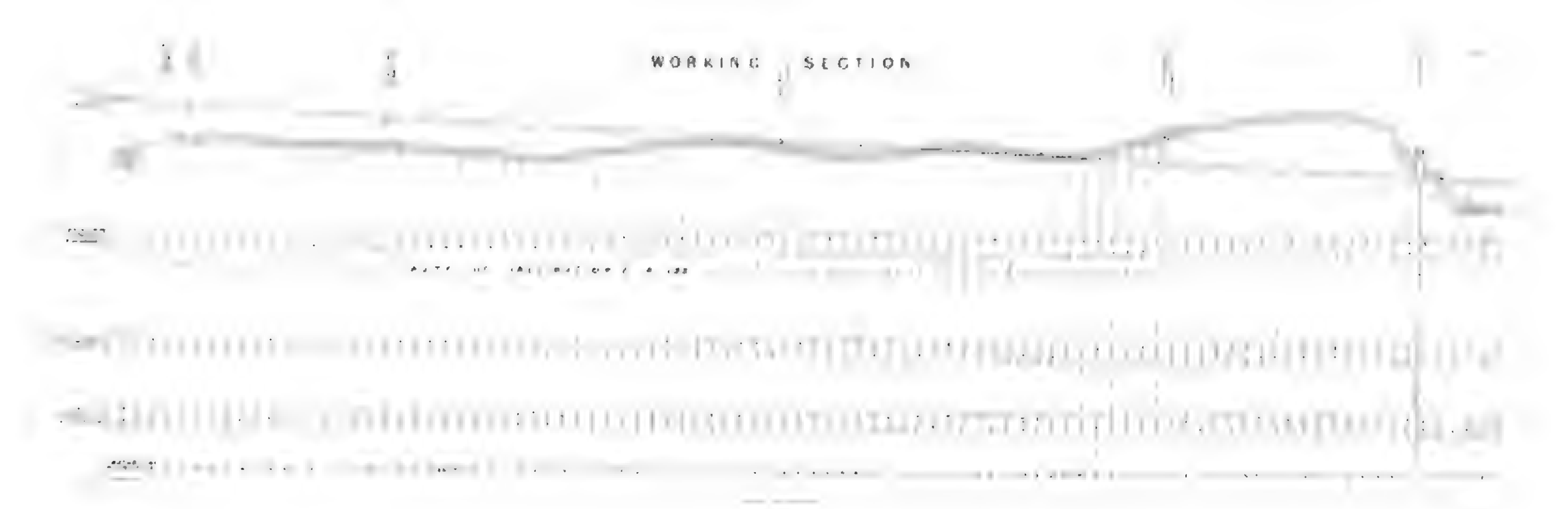


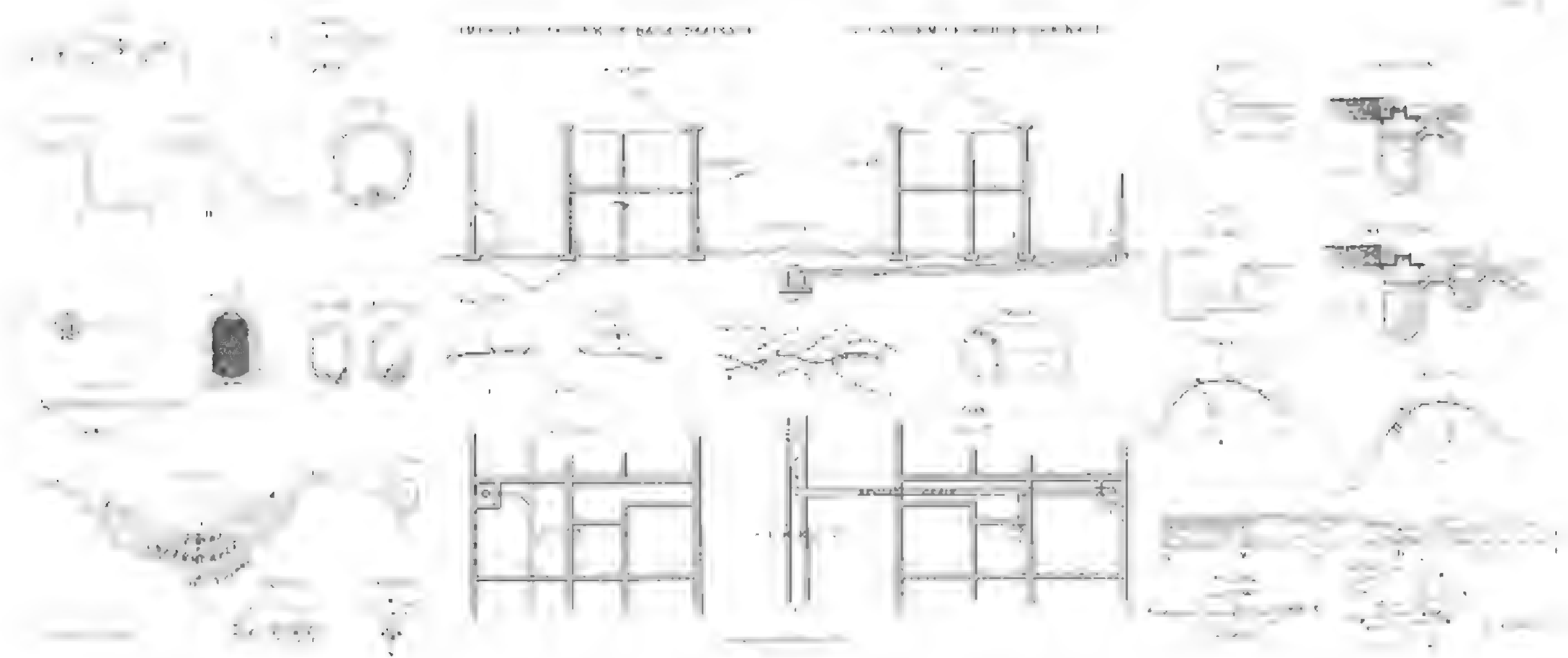



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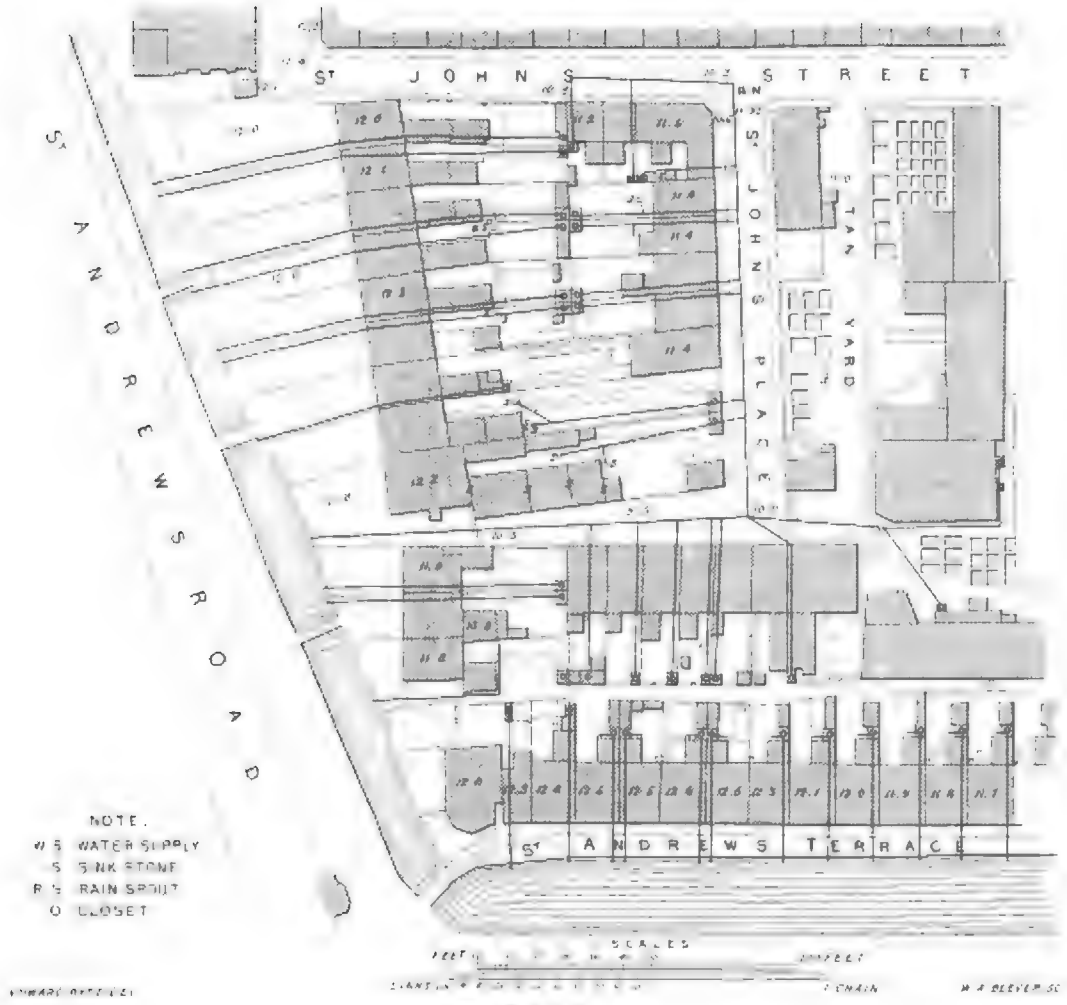





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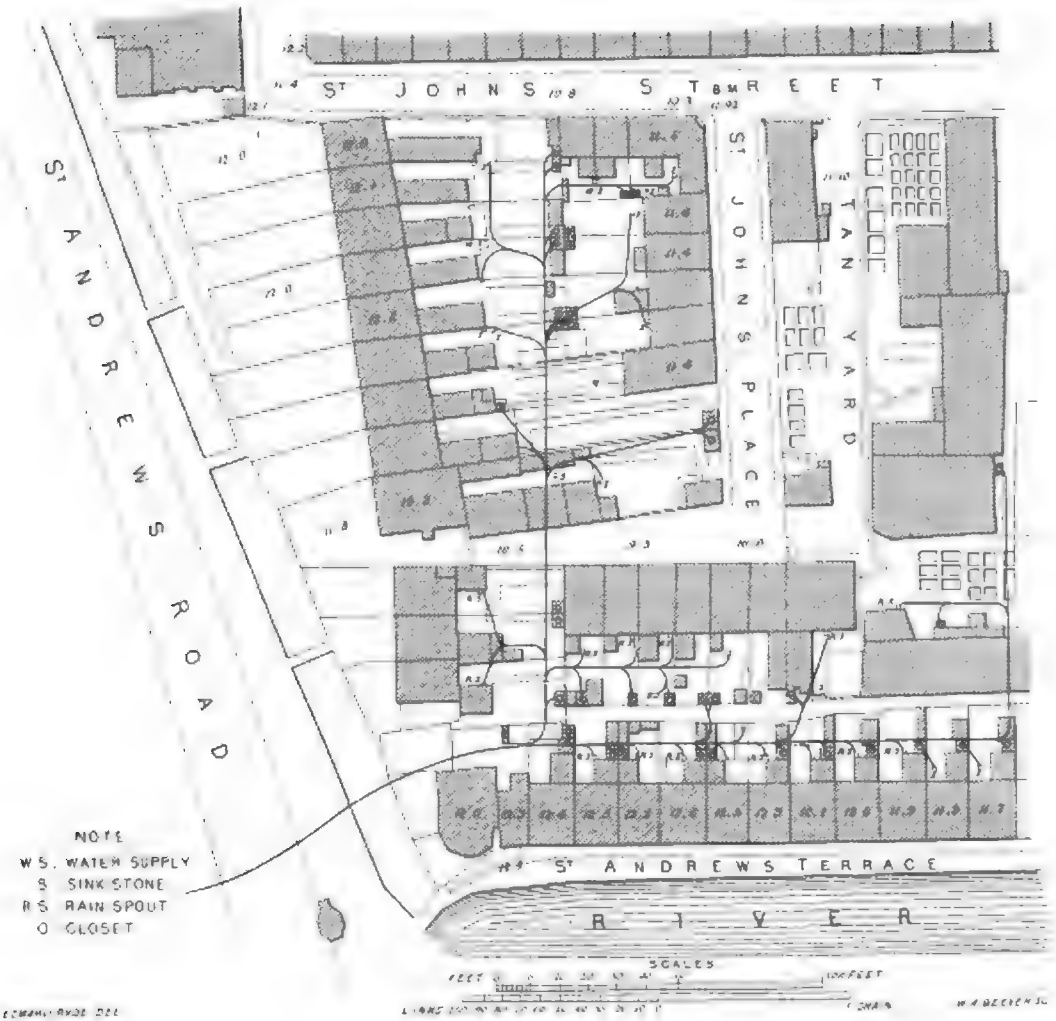


SEPARATE DRAINAGE



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Plate II



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Plan, ditto.
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Details of ditto: transverse section through working gear, transverse section and end view of tender; plan and section of feed-pump; plan and elevation of hand-pump; details of inside framing, centre axle, driving axle-box, regulation-valve, centre-beam stay, &c.
Elevation of Crampton's patent locomotive engine and tender.
Longitudinal section of ditto.
Plan of ditto.
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Elevation of the PYRACMON six-wheeled goods' engine on the Great Western Railway.
Half-plan of the working gear of ditto.
Elevation of a portion of the working gear of ditto.
Diagrams, by J. Sewell, L.E., of resistances per ton of the train; and portion of engines of the class of the GREAT BRITAIN locomotive, including tender, with various loads and at various velocities; also of the additional resistance in lbs. per ton of the train, when the engine is loaded, to be added to the resistance per ton of the engine and tender when unloaded.
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Ditto, drawn and engraved to half-size: fig. 1, old valve, $\frac{1}{16}$-inch lap; fig. 2, $\frac{3}{8}$-inch lap; fig. 3, $\frac{3}{4}$-inch lap; fig. 4, $\frac{3}{4}$-inch lap, Gray's patent; fig. 5, 1-inch lap.
Elevation of a six-wheeled locomotive engine and tender, No. 15, constructed by Messrs. Tayleur, Vulcan, Foundry, Warrington, for the Caledonian Railway.
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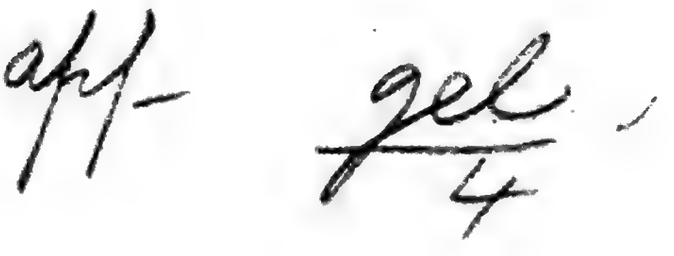
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